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UNIVERSITY AND TECHNOLOGICAL EDUCATION

THE study group set up by the Industrial Research and Education Committees of the Federation of British Industries, including Sir William Larke as chairman, with Sir Percy Dunsheath, K. R. Evans, F. H. Perkins and Dr. B. J. A. Bard (secretary), in its report on the education and training of technologists, offers a useful contribution to the discussion of higher technological education. It does not, indeed, indicate a solution of the problem of qualifications in technology which the Percy Committee frankly avoided; and on the relationship between the universities and technical colleges, although it notes what was emphasized in the Nuffield College report last year, the question of distribution or balance is virtually ignored. The Committee, in fact, appears to accept rather too easily the view that technology is properly studied in the universities at both graduate and undergraduate level, and has scarcely paused to ask whether it is possible that expansion of the technical colleges and an improved status there might relieve the present acute pressure on the universities.

This new report does, it is true, advocate expansion of the technical colleges. It is considered that improvement of existing facilities for the education of technologists should receive high priority, and that an improvement in the quality of technologists will make a greater contribution to the economic recovery of Britain than a further increase in numbers before additional facilities are available, with the attendant risk of lowered standards. It is recognized, too, that advanced studies in isolation may lead to uneducated specialists, and mono-technical colleges are deprecated, except in very special circumstances. The importance of background and the danger of premature specialization are also stressed. It is recommended that greater attention should be given both at school and at college to the development of the capacity for lucid expression in the written and spoken word, and that in all scientific courses and examinations greater weight should be given to this capacity than in the past.

Nevertheless, the Study Group only recommends immediate expansion of facilities for training technologists where a specific need is established relating to a particular technology, though it recommends that laboratories or other facilities required for higher technological studies should be given the highest building priority. It also recommends that where a national need exists, and with the approval of the industries concerned, technical colleges possessing the requisite space and facilities should be raised to the status of national colleges in their appropriate technology or technologies; and work up to and including Ordinary National Certificate standard should be removed from all departments providing education up to degree level.

While the development of a small number of appropriate and suitably located existing institutions into colleges of the character of the Imperial College of Science and Technology—and preferably associated with local universities—is recommended as an

ultimate objective, this, it is held by the Group, should not be at the expense of the development of technological departments at existing universities, or raising the status of technical colleges. The Group dissents from the recommendations in the report on Education and Training of Technologists issued by the Institute of Physics last year for the creation of new colleges or new facilities for the education and training of technologists, except in very special circumstances. The chief emphasis is on strengthening the technological departments of the universities, although the provision of residential facilities at national colleges of technology is urged.

The first recommendation of the Study Group is that the universities should ensure that a higher proportion of their output of technologists during the next few years have received the equivalent of at least one year of post-intermediate study in fundamental science, with an additional one year in the field of applied science with which they are more directly concerned. There follows a recommendation that a higher proportion of the present university population should complete a full three years post-intermediate degree course in fundamental science, and devote a postgraduate year to the more specialized study of a particular technology. To maintain and improve the standard of work of the universities, the expansion of staff and facilities for the adequate accommodation and education of the expanded university population should be the first priority. It is recommended that further general expansion of the number of university students beyond that recommended in the Barlow Report should be deferred until the essential facilities and equipment have been provided to meet the needs of the existing population.

The whole trend of the report and its recommendations shows that the Federation of British Industries Study Group regards the technical colleges as considerably below the universities in status. It recommends, for example, that scholarships and facilities should be provided to enable students with adequate ability to pass from part-time courses in technical college to full-time degree courses in a university. This limited view may be one reason why it favours the encouragement of technology at the universities and the granting of general degrees in technology by the universities themselves, without examining the question whether the teaching of technology in general, or of any particular branch of technology, is an appropriate function of a university. The difference, however, between the study of technology and of an academic discipline is not so much one of status as of kind, and the reason for inquiring whether it would not be wise and appropriate to transfer technological and even professional training from the universities to the technical colleges or to professional institutes is not that such studies are considered unworthy of the dignity of a university: it is rather of choosing the appropriate institution. The functions of the universities and the technical colleges are equally worthy and equally essential, but they are not the same. Nor does it follow that they are equally suited to all types of student.

The Study Group of the Federation of British Industries, preoccupied with the point of view of industry, appears to have overlooked this important consideration. It should be the exception, rather than the rule, for a student to proceed from the universities to a technical college for postgraduate training, or vice versa, as the Study Group appears to envisage. What is required is readier opportunity for such transfer of those students who at the end of, say, their first year, prove more suited by temperament or otherwise to technical rather than academic training. Such transfer of necessity involves something of a common standard of general education in students entering both the universities and the technical colleges, and its attainment would go far to remove the complaint often levelled against the scientific worker and the technologist alike that he is an ill-educated specialist. The importance of such transfer and of mutual freedom of access to university or technical college, whether at undergraduate or postgraduate level, has seldom been recognized.

In a chapter entitled "Studies" in his recent book, Sir Walter Moberly asks some of the essential questions which have to be answered in deciding what should be taught in the universities. He suggests that the proper criterion is to be found in method of treatment rather than in subject-matter; but, while he is prepared to re-examine the reasons for accepting law and medicine as academic disciplines, he scarcely distinguishes clearly between academic education and training for an occupation. The right questions, says Sir Walter, in considering acceptance or rejection of a subject, are these. "What is the proposed syllabus and what are the qualifications of the teachers available? Does it confine itself to imparting 'the tricks of the trade' or does it concern itself with fundamental principles? Cannot the professional training in question be carried on as well anywhere else as in a university? Is the demand a genuine demand for the intellectual improvement of the training available? Can the university undertake the work without prejudice to existing commitments and standards?"

There is a further quantitative aspect to be remembered. While it may be true that the demand for technologists in proportion to men of science in particular sections of industry may tend to decrease as those sections become more scientific, the requirements of industry for technologists will always be greater than its requirements for scientific workers. When all allowance is made for the extension of the practice of training the scientific worker or technologist within industry after graduation, there will always be a greater need of men and women trained to know how to deal with technical problems than of those whose academic education has taught them rather to seek for the 'why' that lies behind the 'how'. Both are required and both are essential; but the former are required in much greater numbers.

On what the proportions should be, this report from the Federation of British Industries gives no guidance. It recommends that each industry not already doing so should ascertain its total requirements of technologists. It does not attempt to define the principles on which differentiation between the universities and

the technical colleges should be based, and its figures give little more guidance than those contained in the Nuffield College Statement last year. There is no indication whether or not the figures of 3,300 scientific workers and 2,100 technologists for the session 1947–48 or the corresponding figures of 5,000 and 3,500 planned for 1952–53 include graduates from the technical colleges as well as the universities. The figures, moreover, require analysis by categories of technology as well as by distribution between universities and technical colleges, and in reference to the studies, already being pursued by Lord Hankey's Technical Personnel Committee, of the estimated demand in particular professions and branches of industry.

While that analysis and comparison are proceeding, some further attempt should be made to arrive at the sound principles of differentiation between the functions of the technical colleges and the universities. Apart from the reference in the Nuffield College Statement, little has been added in the last five years to the admirable passage on technical colleges and universities in the Nuffield College Statement on Problems of Scientific and Industrial Research. A clear conception of the respective functions of the universities and of the technical colleges is essential before the expansion of either can be planned to the best advantage of the nation. It should precede the creation of fresh institutions on the lines and of the status of the Technical Institutes of Zurich and Stockholm or the Massachusetts and California Institutes of Technology, for which there is frequent call—among the latest being one in the Labour Party pamphlet "New Deal for Science". The Federation of British Industries Committee has done well to point out that such institutes are the result of years of patient and devoted effort by a cadre of able and highly skilled professors and teachers building up faculties with a tradition. That effort must be inspired by a clear conception of the purpose to be served, and it must also be viewed in relation to the expansion of the universities and the development of the technical colleges generally. While the Federation of British Industries gives no further opinion on this matter, the Nuffield College Committee last year, like Sir Walter Moberly, emphasized that what distinguish a university are first its range of studies, as contrasted with the more specialized curricula of institutions which are primarily vocational or professional in purpose; and second, the character of the teaching, given typically by teachers who are themselves at work at the frontiers of knowledge in their field. A wide range as distinct from narrow specialization, and an attempt to develop many interests and capacities, are essentials; and while there may be considerable advantage in finding the content of teaching in a professional or practical field, the university's part remains primarily the study of the fundamental sciences that underlie professional studies.

There are two further points to be remembered here. The great majority of occupations involve so restricted a range of theoretical or scientific knowledge that they can be taught just as effectively and much more economically in the occupation than in a university. There is evidence that this is already appreciated by certain sections of industry. The second point is that it is improbable that any considerable expansion of research in the technical colleges, however welcome and desirable, will put the teacher in the technical college in quite the same position at the frontiers of knowledge as his academic colleague. With some exceptions, the advancement of applied science will take place within industry itself, and the vital factor is a ready flow of men to and from the teaching and research staffs of the technical colleges and the research and development staff of industry itself.

On this point the Study Group endorses the recommendations of the earlier report of the Federation of British Industries regarding research in technical colleges; but it makes no fresh suggestions for facilitating the desired interchange of staff. It would seem that there is a wide field to be covered by the promised report on higher technological training from the Advisory Council on Scientific Policy. Even if that report does not re-examine the whole question of the responsibilities of the universities for providing higher professional education, it must at least survey the conditions or principles which should determine the conduct of professional training of any kind in a university. To do so would be a contribution to the definition of those further conditions which should guide the development of specialized but advanced schools for the study and teaching of technological subjects and the professional preparation of teachers, clergy and possibly others. Furthermore, it is required to assist in deciding on the ways in which the universities can best be associated with the work of the technical colleges so as to avoid the dangers which would attend segregation of the latter and concentration on too narrow a range of studies. Even the relegation of technical training generally to the technical colleges need not always preclude the association of such technical colleges with the corporate life of universities when geographical proximity permits.

While this report, therefore, like most of its predecessors, has passed over some vital questions, it has prepared the way for a fuller discussion when the promised report from the Advisory Council on Scientific Policy appears. Nor should it be forgotten that a sub-committee of the University Grants Committee is already considering a question which the 'Working Party' of the Ministry of Education ignored. It is scarcely possible that these further reports can fail to grapple with the main issues, and it may be hoped that the Parliamentary and Scientific Committee, which has also been studying the question, will not hesitate to direct attention to the divided control of higher technological education in Great Britain, which may well be one reason for the inaction of the last three years. This body in particular might very appropriately advance proposals for remedying the defects of such dual control, if indeed it cannot be terminated by extending the responsibilities of the University Grants Committee to include that of higher institutions for technological study.

THE FLORA OF THE NATIONAL PARK OF THE BELGIAN CONGO

Flore des spermatophytes du Parc National Albert 1 : Gymnospermes et choripétales. Pp. lvi+745 (76 plates). 2 : Sympétales. Pp. 628 (54 plates). Par Prof. Walter Robyns. (Bruxelles : Institut des Parcs Nationaux du Congo Belge, 1948.) n.p.

THE Parc National Albert in the Belgian Congo is one of the earliest and largest Nature reserves in the world, and as such, not the least important aspect of its utilization, as an instrument for increasing knowledge of wild life and the technique of its preservation, is an adequate survey of the flora and fauna which the area supports. The two substantial volumes which Prof. Walter Robyns has produced constitute a first instalment in the account of the Spermaphyta.

The original Park, which comprised only two hundred square kilometres at its inception in 1925, has twice been extended, to 3,500 sq. km. in 1929 and to more than 8,000 sq. km. in 1935. Within its confines the altitudes range from 750 m. to 5,000 m., where it includes part of the Ruwenzori massif, while Lake Edward and the adjoining terrain provide aquatic and marsh communities. Thus, with a total area not greatly in excess of that of Devonshire, the National Park provides habitats for some two thousand species of flowering plants.

The history of the botanical study of the area goes back to the late eighties, associated with the Emin relief expedition described by Stanley (cf. *Nature*, **45**, 8 ; 1891). Since then it has been visited by a number of distinguished investigators, and the rich flora has attracted the attention of botanists such as Engler and Fries, while the remarkable tree Lobelias and arboreal Senecios have been the subject of a number of expeditions and publications.

The vegetation types within the Park range from the tropical shade forests of *Cynometra alexandri*, together with a number of associated trees and lianes, which occupy the lower altitudes, to montane scrub. The shade forests extend to 1,750 m., followed by upland forests reaching to 2,300 m. Between 2,600 and 3,700 m. scrub vegetation is dominant, with *Erica arborea* as the most characteristic species, and *Phillipia johnstonii* increasing in abundance as the altitude rises. Above 3,700 m. the forests of the tree Senecios appear with the giant Lobelias as features of the clearings and forest margin.

In the first of these volumes Prof. W. Robyns provides an interesting account of the early history of botanical exploration of the area and a valuable description of the types of vegetation as well as the distribution of the plant communities. Keys are furnished both for the families and species, and, for each of the latter, notes are given concerning the distribution and salient biological features. Apart from the single Gymnospermous species *Podocarpus milanjianus*, the taxonomic text of the first volume is only concerned with the polypetalous families. The best represented of these are the Papilionatæ with 143 species (including 24 of *Indigofera*), Euphorbiaceæ with 57 species (including 10 of *Phyllanthus*), Malvaceæ with 33 species, and Moraceæ with 28 species including twenty of *Ficus*, nearly all the remaining families being represented by less than twenty species. Thus, Cæsalpiniaceæ, Mimosaceæ, Melastomaceæ, Sapindaceæ, Capparidaceæ and Loranthaceæ are each represented by between thirteen and seventeen species. The second volume, which is devoted to the Sympetalæ, contains a higher proportion of well-represented families. The largest number of species belong to the Compositæ, and of the total of 210, *Helichrysum* accounts for 23, *Vernonia* for 26 and *Senecio* for 36. The tree Senecios number seven species, of which *Senecio stanleyi*, *S. erioneuron*, *S. adnivalis*, *S. refractisquamatus* and *S. friesiorum* are endemic to the Ruwenzori massif. Other largely represented families are Rubiaceæ (90 spp.), Acanthaceæ (88 spp.), Labiateæ (64 spp., including 18 spp. of *Coleus*), Asclepiadaceæ (41 spp.) and Scrophulariacæ (34 spp.).

Of the nine Lobelias in the area, five are of the monocarpic type known as giant lobelias, of which three are endemic to the area. *L. Bequærti* and *L. Wollastonii*, both of which grow to between two and five metres in height, occur at an altitude of 3,000–4,000 m. *L. lanuriensis* occurs in the same zone, but will grow to a height of ten metres.

The third volume which is to appear will be devoted to the Monocotyledons and, with those already published, will comprise an admirable inventory of the higher plant life of the National Park and a valuable contribution to the flora of the eastern province of the African region. The excellent full-page plates portray 130 of the more characteristic and endemic types, while half-tone illustrations present the habit and habitat of some sixty species. Prof. Robyns has produced a lasting monument both to King Albert, to whom the work is dedicated, and to himself.

E. J. SALISBURY

APPLIED MECHANICS

Advances in Applied Mechanics Edited by Richard von Mises and Theodore von Kármán. Vol. 1. Pp. viii+293. (New York : Academic Press, Inc. ; London : H. K. Lewis and Co., Ltd., 1948.) 6.80 dollars.

THIS is the first volume of what will undoubtedly be a most valuable series of publications, giving collected accounts of the great advances made in various branches of applied mechanics during the last ten or twelve years. It is well known that many of these researches are still available only in scientific periodicals or in the reports of research institutions ; and it was therefore a very happy idea on the part of Dr. T. von Kármán and Prof. R. von Mises to get a number of experts to write articles which would give a synoptic view of the numerous detailed investigations which have been made in applied mechanics.

These surveys are by no means narrowly confined to work which has been done in the United States. There is a lengthy article by C. B. Biezeno which surveys papers on elasticity, published in Holland during 1940–46, together with an account of the new approach to the mathematical theory of turbulence, by J. M. Burgers, both authors being of the Technical University of Delft. But in the other surveys in this volume something less than justice has been done to workers in Great Britain, although this difficulty may very well be made good in subsequent volumes of this series.

The first section, by H. L. Dryden, gives an admirable survey of recent researches in boundary-layer flow. This consists of a particularly valuable account of

the theory of stability of the laminar boundary-layer flow, together with the theories of Tollmien and Schlichting, and the experimental observations made by Schubauer and Skramstad. N. Minorsky, of Stanford, contributes an interesting discussion of modern trends in non-linear mechanics, which gives a survey of topological methods and analytical methods, together with an account of non-linear resonance and associated phenomena.

The long and detailed article by Biezeno, which surveys Dutch research on elasticity during 1940–46, deals with problems of elastic stability, of the calculations of stresses in plates and shells and of experimental work on shafts, flanges, couplings, ship propellers, flat bars, rotating shafts, etc. The preceding investigations were made at the Laboratory for Applied Mechanics of the Technical University at Delft. Other sections deal with the work done at The Hague and at the National Aeronautical Laboratory, Amsterdam. This last section deals with important practical problems relating to the effective width of thin panels, and of the state of panels after the buckling load has been reached, together with an investigation of the stability of sandwich strips and plates. References are made here to the work done in Germany by Wagner and by Marguerre and Kromm, but there is no reference to the British work by Leggett and Williams.

Burgers's article gives an account of the mathematical model which he has devised to illustrate the analytical and physical problems which arise when we attempt to devise a satisfactory theory of turbulent flow. This mathematical model consists of a system of equations which are much more practicable than the equations of the boundary layer, but which possess many analogies to the boundary layer equations and serve to illustrate in a qualitative way the energy relations of the degeneration of vortices. Miss Geiringer gives an account of numerical methods in wave interaction problems. It is mainly concerned with the computation of shock waves in one-dimensional motions, by a combination of the classical methods due to Riemann and the computational process proposed by von Neumann.

The interesting analytical method devised by Bergman for two-dimensional problems of steady compressible-fluid flow is described by von Mises and Schiffer. The great advantage of the method proposed by Bergman is that he obtains in a closed form integrals of the equation for the velocity potential and the stream function which are valid all over the hodograph plane. It is well known that solutions in the form of power series are only valid in restricted regions, and that a tiresome process of 'patching' is necessary to link up these solutions. Unfortunately, this account of Bergman's method does not deal with the practical problem of constructing solutions to fit practical boundary conditions in the physical plane. Even in the simple case of the flow around a circular cylinder, Bergman's method has not met with great success, and it is a pity that the practical difficulties have not received reference. It also seems a pity that the work done in Britain by Lighthill has received no mention, especially as his investigations seem to be both simpler and more complete than those of Bergman.

We make these few slight criticisms, not in order to detract from the great value of this volume, but as a suggestion to the editors that in future volumes it would be desirable to see that in each topic the whole field of investigations in the United States, in Great Britain, and on the Continent of Europe is satisfactorily covered. Research workers will find that these authoritative accounts, with the extensive bibliographies, are of the greatest value in acquainting them with the work which has been done in recent years, and we hope that successive volumes will appear at short intervals of time until the whole field of this research has been covered.

EXPLORERS ON THEMSELVES

Great Adventures and Explorations

From the Earliest Times to the Present, as told by the Explorers Themselves. Edited, with an introduction and comments by Vilhjalmur Stefansson, with the collaboration of Olive Rathbun Wilcox. Pp. xii+788. (London: Robert Hale, Ltd., 1947.) 25*s.* net.

DR. V. STEFANSSON'S book claims too much and too little. It can scarcely be regarded, in his words, as "an outline of the world told by its chief discoverers from Pytheas to Peary"; nor can it be said that he has secured "historical continuity by leading from one major narrative to the next through summaries of less important ones that belong in between". The first claim is refuted by the fact that nothing is said about the exploration of the interior of Africa, very little about South America, nothing of the interior of North America except what is perhaps incorrectly described as "the first crossing of North America" in 1793 by Mackenzie. Dr. Stefansson seems to have forgotten the adventures of Cabez de Vaca in the early years of the sixteenth century.

The second claim is refuted by the arrangement. The chapter dealing with Magellan's discovery of the Pacific Ocean (*c.* 1519) is followed by one largely taken up with Orellana's voyage down the Amazon (*c.* 1539). Next comes Mackenzie's travels, mentioned above (1793), and then the reader is introduced successively to the "discovery of the north-east passage", including the first voyages of 1553 and the voyage of the *Vega* (1878), "the discovery of the north-west passage", where we jump from Frobisher's third voyage of 1578 to Parry's voyage of 1818, after which there is some continuity in the story, and then back to "north to the Indies", where apart from a brief reference to Robert Thorne we have only the voyage of Hudson in 1607, to "the attainment of the North Pole", which takes us again to the nineteenth century. This method may give continuity of episodes, but gives no continuity of history.

In matters of detail, too, there are numerous errors. It can scarcely be said that Pytheas "was the first known European to cross the Atlantic to the New World". To Dr. Stefansson the "new world" is apparently Iceland. This is certainly not the new world of the explorers of the sixteenth century, nor is it the new world of geographers and historians. And in any event it is not certain that Pytheas ever went to Iceland. It is a pity that Dr. Stefansson relies so much on Markham's paper printed in 1893 when there are later, and better, sources available.

There is also much confusion about John Cabot. He is said (p. 26) to have tried, in 1497, to reach China by going round North America, and later (p. 53) to have begun the search for the north-west

passage. But on p. 155 an entirely different version is given. There his voyages "were hardly in search of a passage round North America even if it be correct to suppose that his second attempt led him up Davis Strait". Later still (p. 475), we are told that he "may have been in search of a passage round America by the north-west in 1497 . . . and still more likely in 1498". Little is known of the beliefs of John Cabot; but it is almost certain that he was unaware of the existence of North America. What then was the point of trying to sail around it, when he almost certainly thought he had discovered part of the coast of Asia or some islands off that coast?

It is possible to find other small points of criticism. The treaty of Tordesillas should be mentioned in the chapter on Magellan; Henry the Navigator was not an explorer; James Cook was not a Yorkshire farmer. All this goes to show that the publishers have overstated their case when they claim that "there has been no book like this before because no one with Dr. Stefansson's knowledge of the subject has ever devoted himself to such a vast undertaking".

On the other hand, the book has the great merit of including many first-hand narratives of explorers. At a rough guess, seven-eighths of this book is of this nature. Some are not particularly useful—the description of Scott's journey in 1902 could profitably have been shortened—but for the most part they cover a wide field and contain much of great interest. This work will therefore be of considerable value as a source-book.

J. N. L. Baker

SEED TREATMENT FOR CONTROL OF FLAX DISEASES

The Diseases of the Flax Plant (*Linum usitatissimum* Linn.)

By Prof. Arthur E. Muskett and Dr. John Colhoun. Pp. 112. (Belfast: The Bursar, Queen's University, 1947.) 21*s*.

MOST of the flax cultivated in Great Britain is grown in Northern Ireland, which provides fibre for the linen made in Ulster. In normal times the supply of home-grown fibre is inadequate, and most of that used in the British linen industry has been imported from Belgium, Holland and the U.S.S.R. In both World Wars, when outside sources of supply were cut off, the acreage under flax increased greatly, reaching peaks of about 110 and 124 thousand acres in Northern Ireland in 1918 and 1944 respectively, the peace-time average for 1936–39 being about 22 thousand acres. Though often highly profitable, it has been an uncertain crop. Unaccountable failures and fluctuations in yield revealed the need for a much better understanding of the troubles encountered in flax growing. It was for this reason that, at the request of the Flax Development Commission, Prof. A. E. Muskett, Dr. J. Colhoun and their colleagues of the Ministry of Agriculture at the Queen's University, Belfast, undertook a study of the pathological problems involved. This book is an outcome of their work on the identification and control of flax diseases.

Some sixteen diseases caused by fungi are simply and clearly described, with advice on their control, explaining why one measure succeeds against one disease and is ineffective against another. Bacterial, virus and deficiency diseases, and one caused by a higher parasitic plant *Cuscuta Epilinum*, are similarly described. There are references to the more important literature with relevant observations on the behaviour of these diseases and their control in other countries. A generous supply of excellent photographs, many in colour, show symptoms on the host and the appearance of the infecting fungi in pure culture, with photomicrographs showing their spores. With the aid of the admirably clear descriptions and illustrations in this book, most of the diseases likely to be encountered on flax in Great Britain should be easily identified. Attention is primarily devoted to the varieties of flax grown for fibre; but the occasional differences in reaction of those grown for the oil in the seed (linseed) are recorded.

The workers in Northern Ireland found that disease spores carried on the seed were among the most frequent cause of unsatisfactory crops. They did not always prevent germination, but often developed some time later and attacked the growing plant. The investigators made a very important contribution to disease control by devising and standardizing a rapid and inexpensive method whereby large numbers of samples of seed can be examined for disease contamination, a method which might well be adapted for use with other crops. During three of the war years they examined annually some 3,000–4,000 samples of seed, the whole of the flax seed output of Great Britain and Northern Ireland. They showed the urgent need for seed disinfection and threw light on the distribution of seed-borne parasites.

This group of workers compared and evaluated different methods of seed disinfection and obtained large increases in yield. Thus in one experiment, the yield of fibre of 3·1 cwt. per acre obtained from untreated seed was increased to 5·9 cwt. per acre by seed treatment and the consequent elimination of seedling blight. It was chiefly due to their work that by 1941 'Nomersan' and later 'Arasan', preparations containing tetramethylthiuram disulphide as the active constituent, were being used to disinfect all the flax seed sown in Britain. The treatment controlled such serious diseases as seedling blight, *Colletotrichum linicola*, and stem-break and browning, *Polyspora Lini*.

No method of seed disinfection, however, gave a complete control of a foot-rot caused by *Phoma* sp., which became very troublesome in 1944 in wetter districts, particularly in Scotland. The disease is often carried on the seed, and so the use of tested disease-free seed is recommended. It is also carried on crop residues, and a long rotation is the next line of defence against this and certain other diseases such as rust *Melampsora Lini* and wilt *Fusarium Lini*. A space of six to seven years without flax is recommended after crops infected with these diseases. Measures for controlling other flax diseases include the use of resistant varieties, crop hygiene, freeing both seeds and crop from infected crop residues, and clean farming so that weeds do not preserve a damp atmosphere favourable to fungi around the plant bases.

The book is admirably produced on good paper with large clear type. It records a considerable achievement in the war-time control of disease, is a notable contribution to our existing knowledge, and provides long-needed information which should eliminate many of the hazards encountered in flax-growing. It will be of great value to the flax-grower, to the plant pathologist and to other agricultural scientists.

Mary D. Glynne

Organic Reagents used in Gravimetric and Volumetric Analysis

By Dr. John F. Flagg. (Chemical Analysis, a Series of Monographs on Analytical Chemistry and its Applications, Vol. 4.) Pp. xiv+300. (New York and London: Interscience Publishers, Inc., 1948.) 36*s*.

TWENTY-FIVE years ago, a publication on the subject of organic reagents would have been a mere pamphlet; to-day, the problem is rather to decide what to omit. The author of this book has met this difficulty, partly by limiting the field to the type specified in the title and partly by dealing mainly with reagents the use of which has been checked in his laboratory. The loss incurred by the former selection is not serious, since many of the compounds used in colorimetric work are dealt with in Vol. 3 of this series of monographs.

Organic reagents as precipitants possess several advantages. Generally, they are much more specific than the classical reagents, and where this feature is less marked, the resulting grouping (cf. Berg's oxine group) is quite different, so that a combination of the two procedures offers obvious advantages. The precipitates obtained are often nicely crystalline so that manipulation is simple, and their usually high molecular weight is reflected in small conversion factors.

The first ninety pages are allocated to a general discussion on organic precipitants, the properties of the precipitates, separations, and a theoretical approach to the problem of solubility—admittedly limited in our present state of knowledge. The rest of the book deals with the practical side. The well-established reagents such as cupferron, the oximes, hydroxyquinoline, nitrosonaphthol, picrolonic acid, nitron, the arsonic acids, anthranilic and quinaldinic acids are treated at some length; naturally, there is more to be said about these than there is about some of the others, for example, benztriazole, mercaptobenzthiazole, quinoline-8-carboxylic acid or the Yoe–Jones reagent for tungsten. Indications are usually given of the accuracy which may be expected and of limitations imposed by the presence of other metals or groups. Adequate operating details are supplied, but, in passing, it is not clear why the nickel–dimethylglyoxime complex should be dried to constant weight at 150° C. in the analysis of nickel steel as against 45 minutes at 110–120° C. in other cases. Altogether, this is a very useful contribution to a most interesting branch of analytical chemistry. B. A. E.

Science in Liberated Europe

By J. G. Crowther. Pp. 336. (London: Pilot Press, Ltd., 1949.) 18*s*. net.

THIS book is based on visits to France, Denmark, Holland and Czechoslovakia in 1946, and it attempts to show how the occupation affected science and men of science in countries now liberated, and the plans which are now being made for the development of science in these countries. The longest account is that of the position in Holland; the sections on France and Denmark are about equal in length, while Czechoslovakia is dismissed in some forty pages. There are some surprising omissions in the account of science in France. Auguste Lumière, in a recent article in *Chimie et Industrie*, perhaps overstressed the lack of originality in current French scientific work; but the cramping effect of bureaucracy in France is probably more important than the cultural idealism which Mr. J. G. Crowther dislikes.

The real defect of the book, however, is its lack of coherence and the slovenly and non-sequential writing, which are even more irritating than the frequent misprints. Mr. Crowther has made little effort to order his material, and he has also attempted to do two things, in neither of which he succeeds. He has jotted down some account of scientific institutions in the countries he visited, their vicissitudes in the War and their present position. To this he has added some random notes on work carried out during and since the War. All this is interspersed with some accounts, often really interesting, of the experiences and escapes of scientific workers during the War.

With the latter material it should have been possible to compile a most fascinating book of real human interest to scientific and general reader alike. As it is, we are given little more than small-talk and trivialities, and the accounts of scientific work are insufficiently self-contained or explanatory for the general reader and neither detailed nor critical enough for men of science. The book is poorly printed and produced; and Macaulay's censure on Croker's edition of Boswell's "Life of Johnson" can seldom have been more deserved. R. BRIGHTMAN

The Lower Palæolithic Cultures of Southern and Eastern Asia

By Hallam L. Movius, jun. Pp. 327–420. (Philadelphia: *Trans. Amer. Phil. Soc.* New Series, Vol. 38, Part 4, 1949.) 1.50 dollars.

THE author specifically states that this work is not an entirely fresh study of the Early Stone Age in south-eastern Asia. It is based on his own field work, for the most part published during the War, particularly in a work entitled "Early Man and Pleistocene Stratigraphy in Southern and Eastern Asia". The present version, however, is intended mainly for those anthropologists and prehistorians who are not primarily interested in geological matters, and such considerations have been omitted, except in so far as a chronological sequence is necessary to make the story intelligible.

The prehistory of southern and eastern Asia is still too little understood and presents interesting problems to the student. The basal cultures seem to be different from those obtaining in Africa and western Europe, and the true Chelleo–Acheulean seems to be absent. Simple, but developing, pebble industries occur, which are replaced, as is universally the case, by others where tools made on flakes predominate. As usual, the general pattern of industrial development is the same as elsewhere in the world, though the several cultures with which the author is concerned show little connexion, as far as is yet known, with the cultural sequences in other, better investigated, regions.

Dr. Movius starts with Java and then passes to Burma, north-western India and finally to northern China. He passes under review the various types of tools discovered, a large number being illustrated. Preliminary tables enable the reader to fit the various cultures into a comparative chronological sequence without having to worry overmuch with the geological investigations which enabled them to be compiled. The original publication on which this is based has long been out of print, and the author is to be congratulated on republishing his field-work in this new and very useful form. All students of southern and eastern Asian prehistory will welcome this study of the basal cultures in these regions. M. C. B.

CHEMICAL COMPOSITION OF THE STRATOSPHERE AT 70 KM. HEIGHT

By Dr. K. F. CHACKETT, Prof. F. A. PANETH, F.R.S., and E. J. WILSON
Londonderry Laboratory for Radiochemistry, University of Durham

FOR various problems in meteorology and physics, it is of importance to know the composition of the earth's atmosphere at all heights. The most direct approach, namely, chemical analysis by laboratory methods, depends on our ability to obtain the samples; the few stratosphere flights by manned balloons have collected air specimens up to 22 km., while pilot balloons have brought back several samples from heights between 25 and 29 km.[1].

The analyses of these samples indicated that, up to about 20 km., the composition of air is still the same as on ground-level, but that above this height the helium content is just slightly greater and the oxygen content smaller. The number, and accuracy, of the analyses was, however, not sufficient to decide whether these changes indicated a diffusive separation of the atmospheric gases beginning at about 20 km., and it was concluded that a successful continuation of the research was to be expected only if air samples from greater heights could be obtained[2].

Such specimens have now been collected. During the past two years, a team of scientific workers in the Department of Aeronautical Engineering of the University of Michigan have developed ingenious methods for sampling, by means of *V*2 rockets, stratosphere air from much greater altitudes than was possible up to now. So far, three successful flights have been carried out and, thanks to Prof. M. H. Nichols and Dr. D. W. Hagelbarger of the University of Michigan, and to Dr. Michael Ference of the U.S. Signal Corps, and with permission of the Meteorological Branch of the U.S. Signal Corps, under the sponsorship of which these experiments are being undertaken, we have received a few cubic centimetres of air from these flights for chemical investigation by our special methods.

As to the sampling device, we owe the following information to Prof. Nichols. *V*2 rockets were fitted with evacuated steel bottles which communicated through a thin-walled tinned copper tube and a break seal to a flushing chamber, through which streamed ambient air from an inlet port in the side of the rocket, being discharged out of a 'reverse scoop' nearer the tail. At a predetermined instant of the flight, the break seal was automatically opened, thus connecting the bottles with the flushing chamber. After a few seconds the bottles were sealed up again by a device which simultaneously heated and squeezed the copper tube. Samples were taken on the free climb. Some of the bottles were recovered, only slightly battered, and a measurement of the pressure of the air they contained was in agreement with that expected for correct working of the mechanism.

The gases were pumped into a series of lime-glass bulbs, some of which were sent to us. These were of 50 c.c. capacity, and contained gas at about 4 cm. pressure, that is, approximately 2·5 c.c. at N.T.P. For each analysis we used 0·2–0·5 c.c. of air. Experience has shown that samples of air that have been stored for some time often have an oxygen content smaller than that of normal air, due to its combination with oxidizable substances. In conformity with our previous procedure[2,3], we therefore determined the ratio of helium and neon relative to nitrogen plus argon; this time, however, we measured also the ratio argon to nitrogen plus argon. In the case of a diffusive separation of the atmospheric gases, the two former ratios should be increased, the latter decreased, and in one and the same sample these changes ought to bear a definite relationship to each other.

The separation of helium and neon[3] and their final measurement in a Pirani gauge[4] were carried out according to the methods previously described, with only minor alterations. One improvement was the reduction of the volume of the Pirani gauge; the 'Pyrex' envelope had now a capacity of less than 10 c.c. This gauge was designed by Dr. W. J. Arrol, now of the Atomic Energy Research Establishment, Harwell, while collaborating with us in war-time research. The main operation in the argon analysis consisted in the absorption of all gases, except the inert ones, by heated metallic calcium, a method originally devised by F. Soddy[5] and used by us in various forms[6], but now greatly refined[7]. The measurement of the purified argon was carried out in a McLeod gauge; results for the argon content of laboratory air always agreed within a probable error of 0·5 per cent over wide ranges of amount of air taken (0·06–0·25 c.c. N.T.P.).

The first step in both the helium–neon and the argon analysis was the removal of oxygen. We were surprised to find that the air samples submitted to us did not contain a detectable amount of oxygen at all; that is, less than 0·1 per cent. It is most likely that the copper tube, which was heated when the metal bottles were sealed off, removed the oxygen by combining with it. In one analysis we looked also for hydrogen, and established that there was certainly less than 0·1 per cent present; but this negative result likewise does not necessarily reveal anything about the original composition of the stratosphere air, as hydrogen could have been absorbed by the walls of the metal and glass vessels.

The results of the argon, helium and neon determinations can be seen from the accompanying table; all figures are related to (nitrogen + argon) = 100. We give here the mean of five determinations carried out on stratosphere air from two different rocket flights; both flights are supposed to have reached the same height of 70 km., and we did not find any significant difference between them.

	Ground-level air	Stratosphere air
Argon	1·160 ± 0·005	1·165 ± 0·005
Helium × 10^4	6·62 ± 0·04	6·34 ± 0·08
Neon × 10^4	22·9 ± 0·1	22·75 ± 0·15

From the figures for the argon and neon ratios, we may conclude that there is no detectable difference between ground-level and stratosphere air. The accuracy of the helium figures is less, but they indicate a deficit of about 4 per cent of helium in our

samples. There are, however, insufficient data available for an accurate calculation of the probable error, and we would not like to give much weight to this result, but hope to repeat the helium analyses with increased accuracy.

Further research also seems desirable for the following reason. After the completion of our analyses, we learned that the aerodynamicists of the University of Michigan believe that there is a possibility of the stratosphere air sent to us being contaminated by ground-level air trapped in the rocket and not completely swept out during the 80 sec. between the firing and the opening of the bottles. They intend in future flights to avoid this danger by an improved design of the collecting system. As the extent of such a possible admixture of ground-level air is unknown, full weight cannot be given to the apparent complete agreement of the argon and neon results, and our figures must be considered as preliminary. Even a 50 per cent contamination with ground air would, however, not invalidate the main result of our investigation, namely, that the chemical composition of stratosphere air at 70 km. is practically the same as that of the troposphere.

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DOUBLE STARS WITH RELATIVISTIC PARTICLES FROM COSMIC RAYS

By Prof. M. COSYNS, Miss C. C. DILWORTH, Dr. G. P. S. OCCHIALINI and Prof. M. SCHÖNBERG*

Centre de Physique Nucléaire, Université libre de Bruxelles

RECENT advances in the manufacture and processing of nuclear research emulsions have made it possible to examine in more detail the nuclear processes induced by cosmic rays. The Bristol group[1] has shown that it is possible, in the new highly sensitive emulsions[2], to detect the beta-decay of the μ-meson and other processes in which relativistic particles are involved. The possibility of processing plates of great thickness (up to 600 microns) afforded by temperature development[3] has brought into use plates in which it is possible to follow to the end even highly scattered particles with a range of several hundred microns in the emulsion.

In a group of Kodak *NT*4 plates 400 microns thick, exposed at the Pic du Midi, we have observed phenomena which could not be detected in the old plates, and have also obtained more accurate information on phenomena already observed.

In recent publications[4,5] the existence of highly charged particles among the products of cosmic ray stars observed in Ilford *C*2 plates has been reported. In our observations we were able to identify by delta-ray counts four heavy fragments from a hundred stars which had five hundred branches. In the electron plates the delta-rays are easily visible, so that even when a highly charged particle leaves the emulsion before coming to rest, its charge can be estimated. In the estimation of the total charge visible in a disintegration, both the existence of heavy fragments and of relativistic particles must be taken into account. Since the sign of the relativistic particles can be either positive or negative, only upper and lower limits to the total charge can be given when such particles are present.

The full statistics will be given elsewhere; but it seemed of interest to describe a certain group of phenomena observed in the course of this investigation.

Fig. 1 shows a heavy particle emitted from a star, which stops in the emulsion after a path of 100 microns and gives rise to a lightly ionizing particle the track of which seems to end in the emulsion after a path of 1,200 microns. We cannot be certain that this particle stops in the emulsion, although it becomes highly scattered, because it is difficult to follow its track to the end in a region rather dense with slow electron tracks. The scattering indicates, however, that the track was close to its end, and thus we can assume that it corresponds to an electron of 1 MeV. energy. Since the track of the heavy particle is very straight and heavier than that of an alpha-particle of the same range, but shows no delta-rays or thinning at the end, we can assume it to correspond to a nucleus of low mass. The two requirements, namely, low atomic number and a maximum energy of beta-decay of a few MeV., are satisfied by helium-6 and carbon-10. Both these nuclei have a life-time of the order of 1 sec. and their decay could be observed in our plates.

Fig. 2 shows a short track (about 10 microns) associated at one end with a star of high energy, and at the other end with a relativistic particle. Because of the shortness of the track, it is not possible to determine either the mass or the charge of this

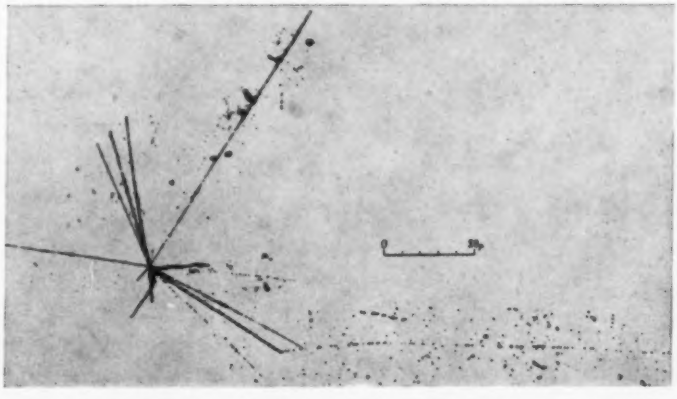

Fig. 1. Beta decay of a light nucleus emitted from a star. Observer, H. Millants

* University of S. Paulo, Brazil, now on leave at the Université libre de Bruxelles.

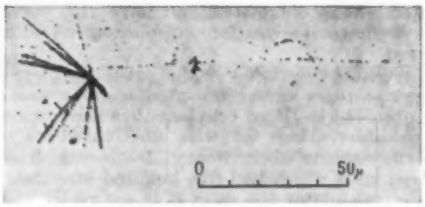

Fig. 2. Beta decay of a short track emitted from a star. Observer, Mme. A. Hubert

particle. This event is most likely the β-decay of a fragment emitted from the star, the energy of the β-ray being rather high. Among eight hundred stars, three examples of this type were found.

We shall now describe a second type of event. In Fig. 3 there is a particle of short range (less than 10 microns) with a star of not very high energy (about 50 MeV.) at one end and a relativistic particle at the other end. Again the very short track does not allow us to make any identification of the linking particle by grain density or scattering. With the relativistic particle are associated short tracks similar to those of low-energy electrons. It is possible that these particles are low-energy electrons ejected during the capture of a meson by an atom, such as have already been observed to accompany the capture of both σ- and μ-mesons, or are due to an excitation of the nucleus during the emission of the two particles. The short thick track could then be a meson coming out of the star giving rise to a relativistic particle, presumably a fast electron, or a σ-meson created together with a relativistic particle (see Figs. 4 and 5).

The fast electron can be accounted for in several ways, namely:

(*a*) The meson decays after being captured by the atom without falling into the nucleus. This mechanism would be extremely improbable if at all possible, in the case of a negative π-meson, because of the extremely short time of capture of a negative π-meson both by the atom and the nucleus, and the necessarily long life-time (greater than 10^{-7} sec.) for an eventual decay of a π-meson, according to the Berkeley results[6]. Although it is unlikely that the emission of a μ-meson by a nucleus has ever been observed, it is not impossible since the μ-meson has necessarily some kind of interaction with nucleons. This event would, however, be very improbable, so that the meson could scarcely be a μ. Finally, there is the possibility of the meson being of a kind different from the π- or μ-meson.

(*b*) The fast electron could be a high-energy Auger electron ejected during the capture of the meson by the atom. The possibility of the emission of a high-energy Auger electron has been pointed out by Wheeler[7]. The meson would then be captured by the nucleus without producing a star, which is quite possible, since an appreciable fraction of captured π-mesons do not produce stars.

(*c*) The fast electron might be a β-ray emitted by the residual nucleus after the capture of the meson and the evaporation of one or more neutrons.

Finally, we shall discuss a third type of event. In Fig. 4 there is a double star: a five-branch star with no relativistic particles, linked by one of its branches to a two-branch star with a relativistic particle. The track of the linking particle has a length of 200 microns and is highly scattered. The high grain-density at this range in the very sensitive plate does not allow us to determine the direction of motion of the linking particle. The high scattering shows that it is a meson. Although the photograph seems to indicate that the scattering increases at the side of the five-branch star, this is not supported by the direct examination of the plate, which shows that the track dips considerably. Unfortunately, the plate was moved during exposure so that the orientation of the particles with respect to the vertical is not known.

This event can be satisfactorily explained by assuming that the meson comes out from the two-branch star and produces the five-branch star, which is of a type often associated with the capture of

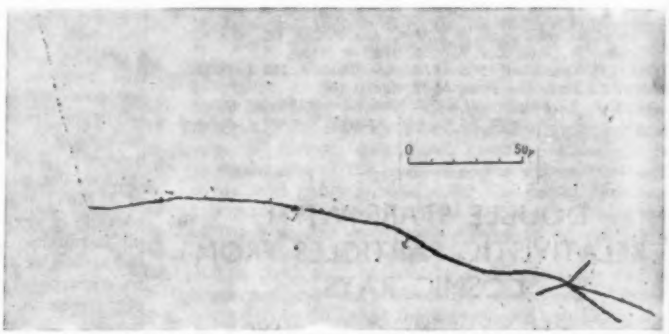

Fig. 4. Relativistic particle linked by a meson to a low-energy star. Two of the apparent β-rays on the track of the meson are slow electrons not originating from the track. Observer, Mlle. E. Frans

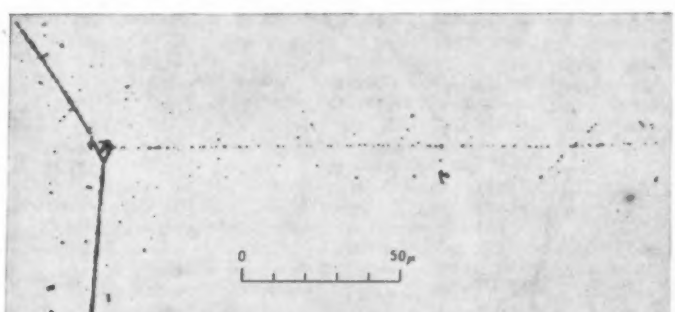

Fig. 3. Relativistic particle and slow electrons linked by a short track to a low-energy star. Observer, Mme. A. Hubert

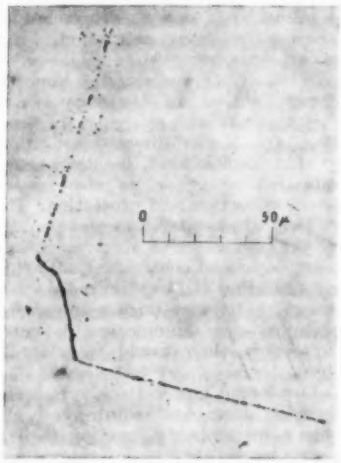

Fig. 5. Relativistic particle linked by a meson to a single high-energy particle. The apparently high grain density in the track of the relativistic particle is due to the great angle of dip in the plate. Observer, E. Shramm

a negative π-meson. Prof. Bohr suggested that the meson was emitted by a neutron which goes over into a proton, which would be the relativistic particle in the two-branch star.

In Fig. 5 we have again a double star—a two-branch star with no relativistic particles, linked to another two-branch star with a relativistic particle. The track of the linking particle is only 50 microns long and seems to correspond to a meson. The other particle in the non-relativistic star is probably a proton of about 30 MeV. energy. In this case the orientation of the plate during exposure is known and shows that if the relativistic particle is coming out of the star it is going downwards. This event seems to be of the same kind as that of Fig. 4. Prof. Bohr's mechanism will also explain this event. We should expect that the outgoing proton carries most of the momentum of the incoming neutron. Since the proton will be moving downwards, as we already pointed out, the fast neutron would also be moving downwards, in the main cosmic ray stream.

Since the direction of motion of the meson in Figs. 4 and 5 is not known, we cannot exclude the possibility that the mesons are produced in each case in the low-energy star and give rise to a relativistic particle at the end of their range. They could then be π-mesons, and the mechanisms which were discussed in this case for the event of Fig. 3 could also be considered for the events of Figs. 4 and 5.

We wish to thank Dr. Rosch and the staff of the Pic du Midi Laboratory for the facilities they accorded us; Drs. Berriman and Herz, of Kodak, Ltd., for supplying the special thick plates used in our observations; and Profs. Bohr, Bøggild and Klein for their interest in our work and for many useful discussions.

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CELL DIVISION

THE Royal Microscopical Society, at a meeting on May 24, held a discussion on "The Mechanism of Cell Division". The president of the Society, Dr. R. J. Ludford, was in the chair.

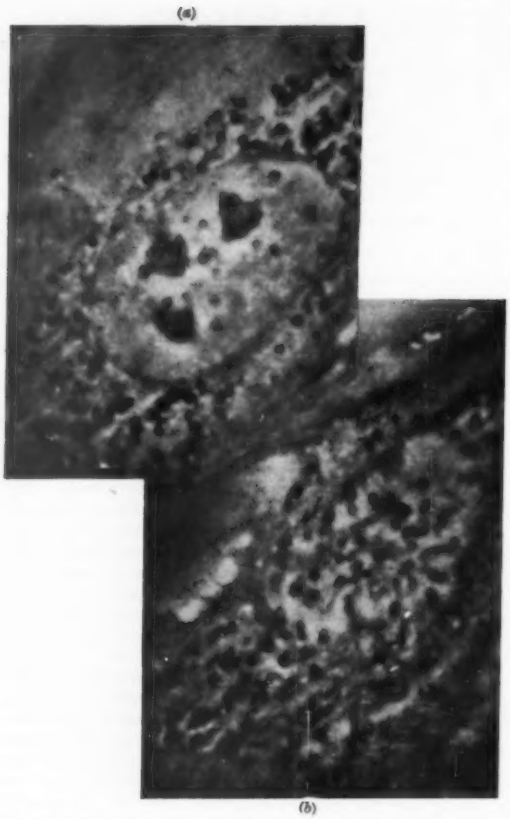
The discussion was opened by Dr. Arthur Hughes (Strangeways Laboratory, Cambridge), who showed films of cells in tissue culture in division, taken with the phase-contrast microscope and the time-lapse camera. The first film, made in collaboration with Dr. H. B. Fell, is of mitosis in cultures of the spleen of the new-born mouse. Among the points shown by this film are these: (1) In prophase, the development of the chromosomes from the interphase chromonemata and chromocentres. The latter, in interphase and early prophase, can be seen in the living nucleus attached either to the nucleoli, or to the inner surface of the nuclear membrane. At the end of prophase the nucleoli are rapidly dissolved, and the nuclear membrane shrinks and vanishes. As the nuclear membrane contracts, the chromosomes which line its inner surface quickly shorten in length [see p. 132]. (2) Polyploid cells can arise by the mitosis of binucleate individuals. At the end of prophase, when the nuclear membrane in each nucleus disappears, both sets of chromosomes join a common metaphase plate. A normal anaphase can follow, and the groups of daughter chromosomes become nuclei of larger size than in normal diploid cells in early interphase.

The second film shows the effects of iodoacetamide, a sulphydryl reactant, on mitosis in cultures of chick osteoblasts. Means have been devised by which a cell in division can be followed under the phase-contrast microscope and a reagent added to the culture at a desired point in the mitotic cycle, with only a momentary interruption of observation and photography. Such a technique is desirable where a substance exerts separate effects at different points of the mitotic cycle. Thus iodoacetamide, for example, prevents the development, and inhibits the action of, the mitotic spindle in prophase and metaphase respectively; but also interferes with nuclear reconstruction in telophase. The latter effect is only seen in cells where anaphase has begun, before the agent is added, and which have thus escaped inhibition in metaphase.

Iodoacetamide in a concentration which in telophase will inhibit the formation of nucleoli, and the assumption by the chromosomes of their interphase condition, have no perceptible effect in prophase within the nucleus. The chromosomes develop, and the nucleoli and nuclear membrane disappear. No spindle, however, is formed, and the chromosomes then coalesce into a static mass.

Mr. M. M. Swann (Zoology Laboratory, Cambridge) described some of the quantitative work which he and Mr. J. M. Mitchison are at present carrying out on mitosis in the egg of the sea urchin, with their sensitive polarizing microscope.

The degree of orientation of the proteins of the spindle and asters is deduced from densitometric measurements on photomicrographs taken with the polarizing microscope. When anaphase begins immediately adjacent to the daughter groups of chromosomes the birefringence of the spindle decreases. A wave of disorientation spreads just ahead of the chromosomes to the spindle poles, and from there travels outwards to the cell surface.



Spleen cell of new-born mouse in tissue culture. (*a*) Early in prophase. Nuclear membrane intact, with nucleoli and chromocentres within. (*b*) 25 min. later. Nuclear membrane shrinking; nucleoli have vanished and chromosomes are almost fully formed. Magnification: × 2,000

These facts seem to indicate that some substance is liberated by the chromosomes from anaphase onwards. Messrs. Swann and Mitchison suggest that this substance may perhaps be a component of the nucleic acids, which are, as Ludford and others have shown, transferred from the cytoplasm to the chromosomes in prophase, and leave the chromosomes again at a later stage. The substance must be effective in very small quantities, since the total volume of the sea urchin chromosomes is only about 1/10,000 of that of the egg. They suggest that the substance may perhaps be a 'structural enzyme'.

Other interpretations of the concentration of nucleic acids on the chromosomes at mitosis have been in terms of synthesis of new genic material and of spiralization of the chromosomes themselves. Messrs. Swann and Mitchison suggest rather that at least some component of the nucleic acids may be involved in producing changes in the protein arrangement of the cell as a whole. The analogy with muscle and adenosine triphosphate is obvious.

A brisk discussion of these two contributions was initiated by Dr. P. C. Koller (Chester Beatty Research Institute, London). He stressed the importance of the phase-contrast ciné-photography in experimental cytology, and pointed out the need for studying not only the immediate reaction shown by cells *in vitro* under the influence of various drugs, but also their recovery, especially the reconstruction of the spindle mechanism after the removal of the chemical agent. Only detailed study throughout the life-cycle of the cell can throw light on the specificity of action of a chemical compound. In referring to Mr. Swann's contribution, Dr. Koller directed attention to the possibility that nucleic acid, besides being required for reproduction of genes, is also necessary for chromosome contraction and protection. He favours the view that the spindle mechanism, which is needed for the movement of chromosomes, is a product of centromere and centrosome, and the 'tactoid hypothesis' of Bernal can explain more specific cases of chromosome behaviour during ana-telophase, for example, chromosome elimination during cleavage division in *Sciara*, than would be possible on Mr. Swann's hypothesis.

Mr. A. Loveless (Chester Beatty Research Institute) suggested that iodoacetate and chloracetophenone are more probably exerting their effect by arresting cytoplasmic enzyme action, especially of the respiratory cycle, rather than in the fashion indicated by Rapkine's theory of reversible denaturation. He accordingly asked whether Dr. Hughes had compared the effects given with those induced by cyanide or anoxia.

Further to the long-held theories concerning the role of —SH in cell division, he reported that it is the conclusion of workers at the Chester Beatty Research Institute that the nitrogen mustards and like compounds exert their profound mitotic inhibitory effects by reaction at sites *other* than —SH, very probably the carboxyl group. He considered that 'mitotic poisons' of the type used by Dr. Hughes and other known —SH-active compounds are active solely through a toxic effect upon cytoplasmic metabolism.

Dr. G. M. Findlay also suggested that Dr. Hughes's experiments on —SH reactants ought to be continued for longer periods, and asked whether any attempts to demonstrate a reversal of the effects had been made. In reply, Dr. Hughes said that iodoacetamide in the concentrations used reacts irreversibly with the greater part of the sulphydryl groups within the cell. Cells in the treated cultures are abnormal in appearance two hours after the application of the agent. It is intended to continue the work with less drastic reactants and to attempt to reverse their action.

In reply to Mr. Loveless, Dr. Hughes said that Pomerat and Willmer showed in 1939 that cell division in cultures is not prevented for some hours by application of cyanide, azide and carbon monoxide in concentrations sufficient largely to inhibit cytochrome oxidase. He therefore does not agree that the effect of sulphydryl reactants is primarily on respiration. The contrast in the action of iodoacetamide on cells in prophase and telophase further points to a more specific action related to cell division.

On the general question of the interpretation of the mitotic process, he urged that we should be more ready to admit that real differences may exist in the features of mitosis in different types of cell throughout the animal and plant kingdom. Too often, he went on, it is assumed that there can be but one uniform and unvarying mechanism of anaphase movement.

Mr. Swann, notwithstanding, spoke strongly against the tactoid theory of the spindle. This theory, said Mr. Swann, has little foundation in fact, except for the rough similarity in shape of spindles

and tactoids. Tactoids, however, look very different from spindles under polarized light; they grow in an entirely different manner, and they never have asters associated with them.

Mr. F. C. Grigg demonstrated sections through the embryo sac of *Lilium* in which the nucleus had been driven to one end of the cell by moderate centrifugal force.

OBITUARIES

Dr. P. H. Cowell, F.R.S.

PHILIP HERBERT COWELL, who died on June 6 last in his seventy-ninth year, was educated at Eton, where his mathematical ability attracted attention. From there he went to Trinity College, Cambridge, in 1889 with an entrance scholarship. He was Senior Wrangler in 1892, and it was said of him—as of other outstanding mathematicians—that he gained more than twice as many marks as his nearest competitor. His astronomical leanings were shown by the award of the Sheepshanks Exhibition and the Isaac Newton Studentship. Like the late Prof. E. W. Brown, who was four years his senior, he undertook research on the motion of the moon, employing the method which was devised but not developed by G. W. Hill. For this work, involving the inclinational terms in the moon's motion, he was elected a fellow of his College in 1894.

In 1896 Cowell was appointed to the newly created post of a second chief assistant at the Royal Observatory, Greenwich. It was soon found that he had neither the taste nor the aptitude for devising or even using instruments; but he excelled in all matters relating to reducing observations and analysing them. At that time the difference between the observations of the moon and Hansen's theory was increasing, and the long series of Greenwich observations gave Cowell an excellent opportunity of comparing the coefficients of the periodic terms with those derived from theory. For the shorter period terms he used the observations from 1847 to 1901, while for those of longer period he used observations back to 1750. His discussion showed essential agreement between the observed and the computed coefficients for all the short-period terms, whether they arise from solar or planetary action or the distribution of matter in the non-spherical earth.

Cowell then went on to discuss the light thrown on the long-scale motion of the sun and moon by ancient eclipses, a subject which has fascinated astronomers for two centuries. To explain the observations he introduced a secular acceleration of the moon of 10·9″, which agrees closely with that found by others; but he found another term which he identified first of all as an acceleration in the motion of the node but attributed later to an acceleration of the sun. In this view he differed from Prof. Newcomb, who placed less reliance on results derived from ancient observations, the interpretation of which may be uncertain.

The work by which Cowell is probably best known was done in co-operation with, and at the instigation of, the late Dr. A. C. D. Crommelin. This concerns the calculation of the orbit of Halley's Comet and that of Jupiter's eighth satellite. In 1907 Cowell and Crommelin undertook the process of computing the motion of Halley's Comet between 1759 and 1910. The elements derived from the observations made at the return of the comet in 1835 could not be used to predict the motion to 1910 without deriving the mean motion from the period 1759–1835, taking account of all the perturbations between 1759 and 1910.

While the calculations connected with Halley's Comet were still being carried out, the discovery of a moving object near Jupiter in 1908 presented new problems to the Greenwich astronomers. After the fact had been established by Dr. Crommelin that this was a satellite of Jupiter, it was clear that the solar perturbations could amount to 10 per cent of Jupiter's attraction, and no theory was available which could take account of these analytically. Cowell decided to apply the method of mechanical quadrature to compute the motion direct from the differential equations in rectangular co-ordinates. Although this merely involved the application of formulæ known from the time of Newton, it had not been thought of before. It had always been found possible to take account of most of the gravitational forces analytically and so get an approximate orbit, the action of the remaining forces producing perturbations to motion in the orbit. Cowell was probably led to his decision by the experience he had had of the need to 'rectify' frequently the basic eclipse in which Halley's Comet was assumed to move.

The success of this simple solution for the gravitational problem in the case of the eighth satellite of Jupiter led Cowell and Crommelin to compute the motion of Halley's Comet between 1759 and 1910 by the same method. Before the end of 1908 they had predicted the time of perihelion as 1910 April 16·61, later corrected to April 17·01. The actual time proved to be 2·68 days later. A final revision indicated that errors of computation and application of the attraction of known bodies could not account for more than a fraction of a day.

In 1910 Cowell was appointed superintendent of the Nautical Almanac Office. He re-organised the work of that establishment and effected a very considerable saving in the cost of the calculations; such success, as might have been expected, did not bring him any benefit. During the final illness of Sir Robert Ball, Cowell undertook lecturing at Cambridge, and it was confidently expected by his friends that he would be elected to a professorship at Cambridge. This was not to be, and Cowell continued to direct the work of the Nautical Almanac Office until 1930, when he retired to live quietly at Aldeburgh in Suffolk.

Cowell was a great organiser of computing and was himself a very rapid and accurate computer. However, he never used a calculating machine, doing all his arithmetic by hand. It is one of the freaks of development that he should originate the direct calculation of orbital motion from the differential equations—by formulæ very suitable for use in machines and now being exploited in the United States and elsewhere.

For his lunar work Cowell was elected a fellow of the Royal Society in 1906, and for that and his later work he was awarded the Gold Medal of the Royal Astronomical Society and an honorary D.Sc. of Oxford. After 1914 he never attended scientific meetings; but he continued to go to Cambridge for Commemoration at Trinity College. H. C. was indeed warmly attached to his College, to which he made a number of bequests. In 1901 he married Phyllis, daughter of Holroyd Chaplin; she died in 1924.

J. JACKSON

Mr. Philip Lake

PHILIP LAKE, who died in Cambridge on June 12, was born on April 9, 1865, at Morpeth, where his father, George Lake, was headmaster of the Grammar School. On leaving school he became a student at the Durham College of Science, Newcastle upon Tyne, where his interest in geology was aroused by the teaching of Prof. G. A. L. Lebour. He gained a scholarship at St. John's College, Cambridge, in 1883 and was placed in the first class of both parts of the Natural Sciences Tripos (1886 and 1887) and was the first recipient of the newly founded Harkness Scholarship for geology. After taking his degree, Lake was appointed to the Geological Survey of India; but for reasons of health resigned after three years and returned to Cambridge. In spite of his short period of service he was able to make some contributions to the geology of India.

This was a difficult period for young geologists, and for some years Lake held no appointment and was engaged in private tuition, examining and lecturing. In 1896 he became principal of the Colchester University Extension College, and spent one half of the week in Colchester and the other half in Cambridge. In 1908 Lake was appointed University lecturer in regional and physical geography at Cambridge, and in 1919 became reader in geography and head of the Department. At first there were few students, and the only accommodation was one room in the Sedgwick Museum and the use of a lecture room. The examinations qualified only for the ordinary degree until the Geographical Tripos was established in 1921. Owing to the excellence of Lake's teaching, which was based on wide learning and a sound knowledge of the physical sciences and mathematics, geography made rapid strides, and when he resigned in 1927 it had become a flourishing Department.

Under the title of "Text-book of Comparative Geology" (1893) Lake translated and edited E. Kayser's "Lehrbuch der geologischen Formationskunde". His "Physical Geography" (1915) met with immediate success, and is still a standard work. With R. H. Rastall he wrote a "Text-book of Geology" (1910), of which five editions have been published. He also contributed articles on regional geology to the "Encyclopedia Britannica". Between 1893 and 1912 Lake gave to the Geological Society the results of his research on the Lower Palæozoic formations of five districts in North Wales. He also wrote on the river system of Wales (1900, 1934), on hill slopes (1928), on mountain and island arcs (1931) and on Wegener's theory of continental drift (*Geograph. J.*, 61; 1923). In palæontology, Lake was an authority on Trilobites and wrote on *Acidaspis* (1896), on Trilobites from Bolivia (1906) and from the Bokkeveld Beds of South Africa (1904). His main palæontological work was a monograph of British Cambrian Trilobites (Palæontograph. Soc., 1906–46). Much of the material for this was poorly preserved and needed patient and prolonged study. In this connexion Lake discovered a method of photographing which eliminated the distortion of the fossils and showed their original form (*Geol. Mag.*, 1943). He was able to give the mathematical proof of this method (*British J. Photography*, 91; 1944).

Lake served on the Council of the Geological Society during 1904–7 and 1927–28, and was awarded the Lyell Medal of the Society in 1912. He was unmarried and outlived all his family and most of his contemporaries, so that his last years seemed somewhat lonely; but he maintained his interests and was always cheerful. By all who knew him he will be remembered as a most friendly and kind man, ever ready to help others. H. WOODS

WE regret to announce the following deaths:

Sir Rowland Biffen, F.R.S., emeritus professor of agricultural botany in the University of Cambridge, aged seventy-five.

Dr. Rudolf Hac, professor of analytical chemistry in the Prague Polytechnic, formerly of the Moravian Agricultural College, whose researches related to the use of thallium carbonate as a volumetric standard and to certain catalytic effects shown by molybdenum compounds, on March 16, aged sixty-six.

Sir Edwin Pascoe, director during 1921–32 of the Geological Survey of India, on July 5, aged seventy-one.

Prof. B. Sahni, F.R.S., professor of botany in the University of Lucknow, and honorary professor in the University of Benares, on April 9, aged fifty-seven.

NEWS and VIEWS

Prof. C. S. Gibson, O.B.E., F.R.S.

PROF. C. S. GIBSON, who is now vacating the chair of chemistry at Guy's Hospital Medical School, has held it with great distinction since 1921. After working with Prof. W. J. (afterwards Sir William) Pope at Manchester and Cambridge, he went in 1912 to India as professor of chemistry in the University of Madras, but was back in England on war service in 1915, when he again collaborated with his old chief on problems of chemical warfare. After a short period as professor at the Medical School in Cairo, he succeeded Prof. T. M. Lowry as head of the chemistry department at Guy's Hospital Medical School. Always an enthusiastic research worker, Gibson maintained an impressive scientific output in spite of the fact that his students rarely specialized in chemistry. He secured considerable expansion of his department, found time to collaborate with his hospital colleagues on various professional problems and devoted considerable energy to studies of chemotherapeutic and dental materials.

Gibson's main scientific interests were in stereochemical problems; in the materials of chemical warfare; in certain natural products (working in collaboration with Sir John Simonsen); and in the chemistry of organic compounds of arsenic and of gold. His most striking successes were the direct method used in the First World War for producing mustard gas; his studies of the sternutatory compound phenarsazine chloride and related substances; and latterly his long series of investigations on the organo-gold compounds, based on an original observation with Pope in 1907. From this also emerged a method for the controlled production of gold films which has proved of considerable practical value. An active member of many scientific bodies, Gibson

was honorary secretary of the Chemical Society for nine years and afterwards vice-president, and he was elected to the Royal Society in 1931. In 1938 he presided over Section B of the British Association. He also did important work as a secretary of the Academic Assistance Council. His successor at Guy's Hospital, Prof. G. A. D. Haslewood, is to be professor of chemistry and biochemistry and will be assisted by a reader in physical and inorganic chemistry.

Leather Industries at Leeds : Prof. D. McCandlish

PROF. DOUGLAS MCCANDLISH, who is retiring from the chair of leather industries in the University of Leeds, was a student in the Department under the late Prof. H. R. Procter. After the award of his M.Sc. degree he became chief chemist in the well-known upper-leather tannery of A. F. Gallun and Sons in Milwaukee, U.S.A. Returning to Great Britain in 1919, he was appointed to the chair at Leeds. Prof. McCandlish's researches have ranged widely within the field of leather technology, on chrome tanning, measurement of *p*H value, the atmospheric deterioration of leather, the molecular structure of collagen in relation to the vegetable-tanning process, and various aspects of the analysis of tannins and leather; he edited the handbook on quantitative tannin analysis for the British Section of the International Society of Leather Trades' Chemists. During the Second World War he was active in overcoming shortages of essential materials. Prof. McCandlish has been president of the International Society of Leather Trades' Chemists, and was its treasurer for about twenty-seven years, up to its dissolution in 1947. He was president during 1926-27 of the British Section (now the Society of Leather Trades' Chemists), and his counsel, always available, has been a great stabilizing influence in the Society. He has been a co-opted member of council of the British Leather Manufacturers' Research Association since its inception in 1920, and chairman of the advisory committee on leather subjects of the City and Guilds of London Institute for more than twenty years. He has also played his part in the social and civic life of Leeds.

Mr. William R. Atkin

MR. WILLIAM R. ATKIN, who is to succeed Prof. D. McCandlish in the chair of leather industries in the University of Leeds, graduated at Leeds with first-class honours in both chemistry and the chemistry of leather manufacture. He was then appointed research assistant to the late Prof. H. R. Procter, and later became assistant lecturer and demonstrator. After service with the King's Own Yorkshire Light Infantry during the First World War, he returned to the University and has been lecturer and senior lecturer under Prof. McCandlish since 1919. Mr. Atkin's research work has covered a wide field, and includes studies on hide proteins, vegetable tannins, the chemistry of chromium compounds, and the deterioration and preservation of vegetable-tanned leathers. In conjunction with the late F. C. Thompson, he re-wrote Procter's "Leather Chemists' Pocket Book", which is recognized as the standard text-book on analysis of materials used in the leather industry. He was a member of a small committee which edited the "Official Methods of Analysis" of the International Society of Leather Trades' Chemists, and has served that Society in many capacities. He was president during 1938–39 and continued as acting-president during the War years. For many years he was honorary editor of the Society's *Journal*.

British Academy

AT the annual meeting of the British Academy, the following were elected officers: *President*, Sir H. Idris Bell; *Secretary*, Dr. R. E. Mortimer Wheeler; *Treasurer*, Sir Frederic Kenyon; *New Members of Council*, Sir Alfred Clapham, Prof. H. A. R. Gibb, Dr. W. W. Greg, Sir David Ross, Sir Percy Winfield and Prof. C. H. Dodd. Lord Russell was elected an honorary fellow, and Prof. C. W. Blegen, professor of classical archæology in the University of Cincinnati, Prof. W. B. Dinsmoor, professor of archæology in Columbia University, New York, and M. Georges Lefebvre, of the Sorbonne, have been elected corresponding members. The following have been elected fellows: Prof. A. J. Arberry, Sir T. Adams's professor of Arabic, University of Cambridge; Dr. R. W. Chapman, formerly secretary to the Delegates of the Oxford University Press; Sir Kenneth Clark, Slade professor of fine art, University of Oxford; Prof. D. C. Douglas, professor of history, University of Bristol; Prof. R. W. Firth, professor of anthropology, University of London; the Rev. W. F. Howard, principal of Handsworth College, Birmingham, and lecturer in Hellenistic Greek in the University of Birmingham; Prof. J. E. Neale, Astor professor of English history, University of London; Mr. R. C. F. O. Pfeiffer, lecturer in classical scholarship, University of Oxford; and Mr. A. E. Popham, keeper, Department of Prints and Drawings, British Museum.

Medal of the Society of Chemical Industry : Dr. Foster D. Snell

ON July 13, during the annual general meeting of the Society of Chemical Industry, held in Whitworth Hall, University of Manchester, the president, Sir David Rivett, presented the Medal of the Society to Dr. Foster D. Snell. Dr. Snell is a consulting chemist and chemical engineer in New York and is an active member of the American Section of the Society of Chemical Industry, of which he was chairman during 1942–44. The Medal is awarded not more than once every two years for conspicuous services to applied chemistry by research, discovery, invention or improvement, or to the Society in furtherance of its objects, and it is not necessarily restricted to a member.

Technical Education in Britain

IN presenting the Education Estimates for 1949–50 in the House of Commons on July 5, the Minister of Education, Mr. Tomlinson, referred to the imperative necessity of staffing the schools and colleges adequately in numbers and in quality, and said that the number of graduate teachers in schools is steadily increasing. While there are difficulties with teachers of science, the position is being closely watched and it is too early to say that the teaching of science in the schools of Britain is in jeopardy through a lack of good graduate recruits to the teaching profession. Of all further education, Mr. Tomlinson said he believes that technical education is to-day the most important; in 1948 the Ministry approved final plans for projects for technical education to cost nearly £2 million, and preliminary plans for another £3·5 million. He said he is going ahead with the

establishment of national colleges of technology wherever industry is prepared to co-operate, and five are already open. A further one at Bradford for wool has been approved in principle, as well as two others. Other problems in the higher technological field are being considered by the National Advisory Council on Education in Industry and Commerce in consultation with the University Grants Committee.

University Entrance Awards and Scholarships

With regard to university awards and scholarships, Mr. Tomlinson announced that he proposes to carry out the recommendations made by the working party on this subject in Chapter 4 of its report. These recommendations, which are to be put into effect forthwith, include revision of the income scale for parental contributions on more adequate and up-to-date lines, the assessment of grants and contributions on the basis of a full year, and larger children's and education allowances. There is also to be an increase by one hundred this year in the number of State scholarships. The vice-chancellors of universities and the local education authorities are already in consultation about a procedure for local awards under which full weight will be given to the recommendations of universities on the merits of students. He hoped in the future to tidy up the grants to intending teachers; but this must be done by stages. Before long he hoped to abolish the system of four-year grants based on an undertaking by the individual teacher. Mr. Tomlinson did not think that there is any evidence that the standard of students leaving the schools has declined.

The Minister has thus accepted substantially the recommendations made earlier in a report "Entrance to the Universities" prepared by the Education Advisory Committee of the Workers' Educational Association and adopted by the annual conference in October 1948. A "Comment" on the working party's proposals now appended to this report expresses the view that, if fully implemented, the working party's report should provide the best means of discovering the real scale of the demand for university places and how far the supply is adequate. It should pave and not block the way for the inquiry into a long-term policy with regard to the universities which was urged in the report from the Workers' Educational Association's committee and endorsed by the conference. These questions, it was urged, should be investigated by a committee consisting of representatives of the universities, the Ministry of Education, the Treasury, teachers, industry and men and women representatives of other aspects of our national life. Besides the number of university places to be provided and the question of the selection of university students, the function of the university in the national life of Britain, the length of the university course, the proportion of general and special education in a first degree, the recruitment and training of university teachers, adult students at universities and the interchange of students with the Dominions and overseas generally were recommended for investigation.

Electric Power Engineering in Germany during the War

B.I.O.S. Overall Report No. 11 ("Electric Power Engineering in Germany during the Period 1939–1945." Pp. 56. London: H.M. Stationery Office. 1*s.* 3*d.*) reviews developments in electrical power practice under five headings: turbines, generators and motors; switchgear, transformers and other equipment for the transmission system; power cables; mercury-arc rectifiers; batteries and battery traction. Each section of this publication, which, in fact, epitomizes a group of individual summary reports, presents a picture of the position in that field in Germany at the end of the War, makes some assessment of the most significant developments and contrasts the German position with that existing in Great Britain. This last-mentioned feature adds greatly to the value of the document. The report concludes with an extensive list of references to other detailed reports and to original German documents, and is not only an informative record but also constitutes a valuable critical comparison of British and German development. It merits the attention of all concerned with either the manufacturing or the supply side of the electrical industry.

Astronomy Gallery at the Science Museum, Kensington

The Astronomy Gallery at the Science Museum, South Kensington, London, S.W.7, is now fully open to the public after having been closed since the outbreak of the War. Among the many exhibits once again on view are historic telescopes, models of the solar system including an orrery made for George III, sundials, sextants and several historic globes. An exhibit now shown for the first time is one presented by H.M. The King—a globe upon which is engraved a representation of the visible surface of the moon. Constructed by John Russell, R.A., in 1797, the globe is known as a selenographia, and it is supported in a complicated mounting upon which the motions of the moon can be demonstrated. In the course of a month the moon, as seen from the earth, appears to oscillate slightly, and a small part of the surface, first on one edge and then on the other, is exposed. The result is that 59 per cent of the surface can be observed; but the other 41 per cent has never been seen. The mechanical mounting of the selenographia enables these oscillations, or 'librations', of the moon to be demonstrated in detail.

Training for Management

An interesting attempt to provide training for management for students who have had little or no industrial experience has recently been announced by the Leicester College of Technology and Commerce. The course has been arranged to combine courses of study with the acquiring of practical experience. All students have to be nominated by a firm or organisation with whom they are working, and are required to attend at the School of Commerce for three separate months of residence spread over a total period of thirteen months. During the remaining ten months a course of directed reading is prescribed, suitable study notes being provided by the College; each student is required to attend the College for tutorial sessions on two occasions during each reading period. The course itself will cover the Common Intermediate Examination in Management and will allow the student to sit for the National Diploma in Management after a further two years of part-time study.

Experimental Cell Research

A new journal entitled *Experimental Cell Research* is being issued under the auspices of the International Society for Cell Biology. It will publish papers dealing with experimental analysis of the

activity, structure and organisation of the cell and its sub-units, including work on viruses. Technical or theoretical papers aiming at the further development of methods in the field of experimental cytology will also be included. Papers may be submitted in English, French or German. It is being edited by Prof. Tōrbjorn Caspersson, Stockholm; Dr. Honor Fell, Cambridge, England; Prof. John Runnström, Stockholm; Dr. Francis O. Schmitt, Cambridge, Massachusetts; Dr. Paul Weiss, Chicago, Illinois; Dr. Ralph W. C. Wyckoff, Bethesda, Maryland. Prof. J. F. Danielli, London, will act as editor of communications from the Society for Cell Biology. Authors residing in the Americas should send their papers to the American editors; those residing in the British Isles should communicate with Dr. Honor Fell, Strangeways Laboratory, Cambridge; papers originating in other countries should be forwarded to the Scandinavian editors. One volume, consisting of four issues, will be published annually, by the Academic Press, Inc., New York.

Latin American Scientific Institutions and Workers

THE Latin American Conference of Scientific Experts, held in Montevideo during September 1948, recommended to Unesco the importance of publishing a classified list of Latin American scientific institutions and men of science. The Latin American Unesco Field Science Co-operation Office established in Montevideo is making an inquiry for this purpose; at present this inquiry is almost complete for Colombia, Ecuador and Uruguay, while it is at an advanced stage for the Argentine, Brazil, Chile, Bolivia, Peru, Cuba, Mexico, Paraguay, Puerto Rico, San Domingo, Venezuela and Honduras. The aim of this inquiry is to collect data on scientific workers, institutions and societies (addresses, activities, publications, special items, etc.) in order to have a complete set of biographical and technical information to publish later on. All Latin American scientific workers and organisations are invited to send any possible information on their activities to Centro de Cooperación Científica para América Latina de la Unesco, Agraciada 1875, Montevideo.

Cambridge Scientists' Anti-War Group

A CAMBRIDGE Scientists' Anti-War Group has been re-formed; the officers are: Dr. W. A. Wooster (chairman), Mr. P. A. Jewell (secretary), Dr. S. F. Boys (treasurer), and all inquiries should be addressed to 339 Cherry Hinton Road, Cambridge. It is proposed to study and report on questions of international co-operation in science, on factors determining the attitude of the public to war, on the causes of the failure of previous peace treaties and disarmament proposals, on the biological aspects of atomic warfare and bacteriological warfare, and to present alternative contributions which science could make to human welfare if not deflected into war preparations.

1851 Exhibition Overseas Research Scholarships for 1949

THE Royal Commission for the Exhibition of 1851 announces the award of overseas science research scholarships for 1949 to the following for research work to be carried out at the universities stated. J. R. Allen (Queen's University, Kingston, Ontario), physics at Bristol; G. E. Lee-Whiting (University of Toronto), physics at Bristol, Cambridge or Manchester; D. E. Caro (University of Melbourne), physics at Birmingham or Cambridge; R. L. Martin (University of Melbourne), chemical physics at Cambridge; R. Gradwell (University of Queensland), geology at the Imperial College of Science and Technology, London; L. C. Vining (University of New Zealand), organic chemistry at Cambridge; A. Klug (University of Cape Town), physics at Birmingham, Bristol or Cambridge; K. G. Ramanathan (Indian Institute of Science, Bangalore), physics at Cambridge; M. T. Chaudhary (University of the Punjab), organic chemistry at London; J. E. J. Gowan (National University of Ireland), organic chemistry at University College, London. The scholarships are of the value of £350–400 a year and are ordinarily tenable for two years.

Institution of Electrical Engineers: Premium Awards

THE Institution of Electrical Engineers has made the following awards of premiums for papers read or accepted for publication during the session 1948–49. *Kelvin Premium:* C. W. Earp and R. M. Godfrey. *John Hopkinson Premium:* G. F. Shotter. *Non-Section Premiums:* A. Hamilton and Dr. R. W. Sillars (Llewellyn B. Atkinson Premium); Dr. J. H. Walker (extra premium). *Measurements Section Premiums:* Prof. F. C. Williams and T. Kilburn (Silvanus Thompson Premium); G. T. Winch (Mather Premium); H. M. Gale and P. D. Atkinson (extra premium). *Radio Section Premiums:* G. Millington (Duddell Premium); Dr. G. F. Gainsborough (Ambrose Fleming Premium); and extra premiums to H. de B. Knight; Dr. W. A. Wooster, Dr. Nora Wooster, J. L. Rycroft and L. A. Thomas; Dr. D. G. Tucker; Dr. B. G. Pressey; Dr. H. G. Hopkins and F. Horner; C. F. Floyd and R. L. Corke; C. F. Booth and J. P. Johns; H. T. Mitchell and T. Kilvington; F. E. Williams. *Supply Section Premiums:* H. M. Lacey (Sebastian de Ferranti Premium); H. Headland (John Snell Premium); C. H. Flurscheim and E. L. L'Estrange (extra premium). *Utilization Section Premiums:* B. Adkins and W. J. Gibbs (Crompton Premium); T. P. Wakeford (Swan Premium). *Fahie Premium:* W. H. Grinsted. *Paris Exhibition (1881) Premium:* H. W. Grimmitt. *Webber Premium:* C. Crampton, W. Struszynski, S. de Walden and P. G. Redgment. *Overseas Premium:* Dr. H. D. Einhorn and J. D. Sauermann.

Announcements

THE Managers of the Royal Institution have awarded the Actonian Prize for 1949 of one hundred guineas to Sir Alexander Fleming, for his paper published in 1945 entitled "Penicillin—Its Discovery, Development and Uses in the Field of Medicine and Surgery". The Prize has been awarded every seventh year since 1838 under a trust established in that year by the late Mrs. Hannah Acton.

CENTENNIAL symposia on "The Mineral Nutrition of Plants" and "Plant Growth Substances" are being arranged by the University of Wisconsin and will be held at the Memorial Union Theatre during September 1–3 and 5–7, respectively. In addition to the formal papers, there will be separate sessions for informal discussions. Further information may be obtained from Mr. R. P. Lee, Division of Residence Halls, Slichter Hall, University of Wisconsin, Madison 6, Wisconsin.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Evidence for α-Protein Structure in Polypeptides

CONTINUING our work on the structure of synthetic polypeptides[1,2] we have recently spun fibres of a number of these products. The following is a preliminary review of the results of an X-ray examination of two—a copolymer of L-glutamic γ methyl ester with DL-β-phenylalanine (*A*), and poly DL-β-phenylalanine (*B*). Figs. 1 and 2 are X-ray photographs of the former in disoriented and oriented states respectively; Fig. 3 is a photograph of oriented fibre *B*. These diagrams show that both polymers have very similar structures. In *A*, the repeat along the fibre axis is 5·26 A., and it is possible that the intense equatorial reflexion can be resolved into two spacings of 11·7 A. and 11·2 A.; the angular dispersion of the former arc is much greater in this particular specimen. The 11·7 A. and 11·2 A. spacings, therefore, appear to orient to different extents on stretching. In the powder diagram of the fibre, Fig. 1, the spacings are not resolved, and give a mean of 11·4 A. In *B*, the repeat along the fibre axis is 5·28 A., and the equatorial arc may perhaps again be resolved into a doublet of spacings—12·8 A. and 11·7 A. These two overlapping arcs again show differences in angular dispersion, that at 12·8 A. being the greater, but this is not so marked as in the former case.

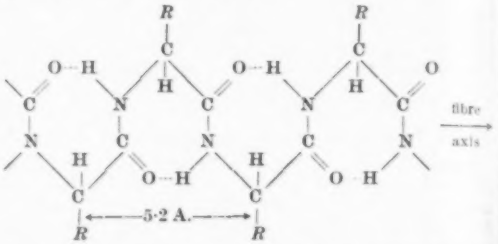
It is possible from these photographs to suggest, at least provisionally, a unit cell (or sub-multiple) for each of the polymers, of the following dimensions.

	a(A.)	*b*(A.)	*c*(A.)	Mean residue weight
A	11·7	5·26	11·2	145
B	12·8	5·28	11·7	147

In films of these polymers it appears that the *c* axis tends to lie perpendicular, while the *a* axis is most probably parallel, to the plane of the film (see also the results of Astbury *et al.*[3] for film of copolymer of D-leucine and DL-β-phenylalanine). An unambiguous assignment of the cell dimensions is not possible on these data; but if the cell were orthorhombic (as is believed to be the case with α-keratin) but with two chains per unit cell, and each chain containing two residues in the repeat distance of approximately 5·2 A., that is, four residues per unit cell, these figures would correspond to densities of *A* of 1·38 gm./c.c. and *B* of 1·24 gm./c.c. Preliminary density measurements on these polypeptides are: (*A*) 1·33 gm./c.c. and (*B*) 1·23 gm./c.c., which are in reasonable agreement with the calculated figures given above.

A detailed comparison of Fig. 3 and Fig. 1*f* of Astbury *et al.*[3] shows the similarity of the two diagrams, that is, the latter is essentially a fibre-type α-protein diagram. It must, however, be borne in mind that in Astbury's model of α-keratin, the repeat of 5·15 A. along the fibre axis contains three amino-acid residues, whereas in the present work it is suggested that the α-fold in the polypeptides contains only two.

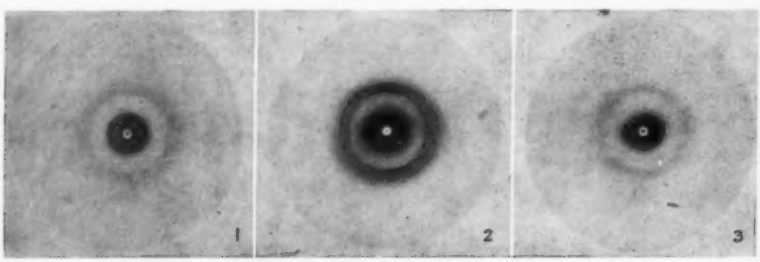
From the above results, the resemblance of these polypeptides to α-protein in respect to the repeat along the fibre axis can clearly be seen, and there is no evidence of a β- or cross-β-structure. The repeat distance along the fibre axis is in agreement with the structure shown below:



and it is unnecessary to postulate the abnormal backbone spacing given by Astbury *et al.*[3] for certain polypeptides. Work on the sideways packing is in progress. Ambrose and Hanby[1], in a study of the infra-red absorption of a film of poly-L-glutamic γ-methyl ester, put forward the above structure to account for the observed parallel dichroism of the strong N—H stretching frequency at 3,300 cm.$^{-1}$. Recent work in these Laboratories by Elliott, Ambrose and Temple has shown that orientated films of polymers *A* and *B* exhibit a similar parallel dichroism.

Although these fibres have been oriented by stretching, we have not been able to extend them into a β-configuration. If the polypeptide chain is coiled as in the structure indicated above, the interchain hydrogen bonding will be very small, and unless there is considerable side-chain interaction the crystallites will slip past each other comparatively easily on stretching. The failure to obtain a β-form is therefore not surprising, especially in view of the fact that models of the α-chain show that the hydrogen bonds are operating with a considerable mechanical advantage. Such would not be the case with α-keratin, in which interchain association occurs mainly through S—S and salt linkages, thus establishing a net structure which will not slip so easily.

Since this work was completed, Brown, Coleman and Farthing[4] have published an X-ray study of the copolymer of L-leucine and DL-β-phenylalanine. We have studied these photographs and feel that their results can be equally well explained by the above ideas, without assuming that the chains lie per-



X-Ray photographs of: (1) disorientated fibres of copolymer of DL-β-phenylalanine and γ-methyl L-glutamic ester (mol. ratio 1 : 1); (2) orientated fibres of copolymer of DL-β-phenylalanine and γ-methyl L-glutamic ester (mol. ratio 1 : 1); (3) orientated fibres of poly DL-β-phenylalanine
Copper *Kα* radiation. *D* ≈ 2 cm. (reduced from 4 cm. on reproduction)

pendicular to the fibre axis, and without postulating what is essentially a 'backbone spacing' of 4·65 A. as a repeat of 5·2 A. along the fibre axis.

We are indebted to Dr. A. Elliott for very helpful discussions, and to Drs. S. G. Waley and J. Watson for help with the synthetic work.

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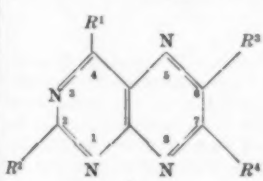
[1] Ambrose and Hanby, *Nature*, **163**, 483 (1949).
[2] Ambrose, Elliott and Temple, *Nature*, **163**, 859 (1949).
[3] Astbury, Dalgliesh, Darmon and Sutherland, *Nature*, **162**, 596 (1948).
[4] Brown, Coleman and Farthing, *Nature*, **163**, 834 (1949).

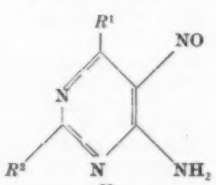
A New Synthesis of Pteridines

There is a growing biological interest in derivatives of pteridine (I : R^1, R^2, R^3, R^4 = H) as a source of antagonists for folic acid (I : R^1 = OH ; R^2 = NH_2 ; R^4 = H ; R^3 = .CH_2.NH.C_6H_4.CO.NHCH(COOH)-CH_2CH_2COOH-*p*), since this vitamin plays an important part in the growth of certain bacteria and normal and malignant tissue. Thus, Hertz[1] has reported that abnormal growth in the chick genital tract evoked by stilboestrol was inhibited by methyl folic acid (*I* : R^1 = OH ; R^2 = NH_2 ; R^4 = CH_3 ; R^3 = .CH_2.NH.C_6H_4.CO.NHCH(COOH).CH_2CH_2-COOH-*p*), which is a powerful antagonist (Martin *et al.*[2]), an effect which was reversed by giving folic acid. Little *et al.*[3] and Woll[4] have reported inhibition of growth of the Rous chicken sarcoma by means of antagonists, and Bass and Freeman[5] found that the inhibition of a lymphoma (lymphosarcoma 6C3HED) in the mouse by mustard gas was to some extent prevented by giving folic acid. Meyer[6] claims a favourable clinical effect in acute leukæmia with methylpteroic acid (I : R^1 = OH ; R^2 = NH_2 ; R^4 = H ; R^3 = .CH_2.N(CH_3)C_6H_4COOH-*p*). Other antagonists of simple structure are reported by Daniel *et al.*[7].

Hitherto, pteridines have been synthesized essentially by condensation between the appropriate 4 : 5-diaminopyrimidine and a suitable structure containing adjacent carbon atoms (which are to take up positions 6 and 7 (I)), with substituents R^3 and R^4. Where R^3 and R^4 are different, a mixture of isomers may be formed, leading in some cases to a relatively poor yield of a compound of undetermined structure. The precise positioning of a substituent in the 6 or 7 position is important since (I) (R^1 = OH ; R^2 = NH_2 ; R^4 = OH ; R^3 = .CO.NH.C_6H_4.CO.NH.-CH(COOH)CH_2CH_2.COOH-*p*) is a much more potent antagonist than the isomer with R^3 and R^4 substituents interchanged (Woolley and Pringle[8]).

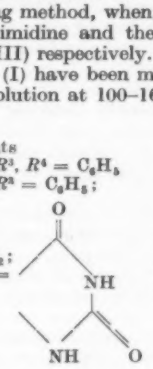
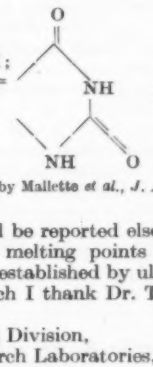


I



II

It therefore appeared desirable to seek a new method of synthesis which would avoid the disadvantage of isomer formation and ambiguity about the structure of the product, and it has now been found that 5-nitroso-4-aminopyrimidines (II) condense readily with ketones (III) and related ring structures, which contain suitably active and adjacent methylene and carbonyl groups, to yield pteridines of type (I). The new route involves two fewer stages than the existing method, when, as is often the case, the diaminopyrimidine and the diketone are made from (II) and (III) respectively. The following compounds of type (I) have been made by condensation in acetic acid solution at 100–160° C.

Substituents	Melting point or absorption spectrum	Maxima		Minima	
		λ	log ε	λ	log ε
R^1, R^2 = NH_2; R^3, R^4 = C_6H_5	282° *				
R^1, R^2 = NH_2; R^3 = C_6H_5; R^4 = CH_3	330°				
R^1, R^2 = NH_2; R^3, R^4 = 		264 369	4·11 4·34	294	3·59
R^1, R^2 = OH; R^3, R^4 = 		280 388	4·2 4·3	275 322	4·16 3·4

* Previously made by Mallette *et al.*, *J. Amer. Chem. Soc.*, **69**, 1814 (1947).

This work will be reported elsewhere later in more detail. Where melting points are not applicable, purity has been established by ultra-violet absorption spectra, for which I thank Dr. Tudor S. G. Jones.

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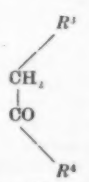
[1] Hertz, *Science*, **107**, 300 (1948).
[2] Martin *et al.*, *Arch. Biochem.*, **12**, 318 (1947).
[3] Little *et al.*, *Trans. New York Acad. Sci.*, (ii), **10**, 91 (1948).
[4] Woll, *Trans. New York Acad. Sci.*, (ii), **10**, 83 (1948).
[5] Bass and Freeman, *J. Nat. Cancer Inst.*, **7**, 171 (1946).
[6] Meyer, *Trans. New York Acad. Sci.*, (ii), **10**, 99 (1948).
[7] Daniel *et al.*, *J. Biol. Chem.*, **169**, 689 (1947).
[8] Woolley and Pringle, *J. Biol. Chem.*, **174**, 327 (1948).

Hydroxylamine Assay of Penicillin

In order to obtain a satisfactory chemical method for the determination of penicillin which might be applied throughout the penicillin production process from fermenter broth to final product, the hydroxylamine method of Staab, Ragan and Binkley[1], which was modified by Ford[2] to include the assay of broth, was investigated in these laboratories.



III

The coloured compound produced by the reaction of the hydroxamic acid and the ferric chloride was found to be much more stable in *n*-butanol solution than in aqueous solution, although the very rapid fall in colour intensity, described by Ford,

was not experienced. The accuracy and convenience of the method was thus improved by extracting the complex into *n*-butanol before colour measurement. The need for making additions to the colorimeter cell was also eliminated in this way, as was the difficulty of gas evolution on the addition of the ferric chloride reagent, which made accurate colour reading almost impossible.

In the case of fermenter broths containing corn-steep liquor, it was necessary to extract the penicillin into *n*-butanol by a salting-out procedure using a fixed concentration of between 10 and 15 per cent w/v of ammonium sulphate.

Solutions of penicillin in solvents such as butyl acetate were satisfactorily analysed by addition of all the reagents to the solvent solution, followed by sufficient *n*-butanol to extract the colour into the solvent phase and measurement of the colour in this mixed solvent medium.

The lower concentration limits to which the modified method could be applied in pure aqueous solution fermenter broth and butyl acetate solution were respectively 150, 150 and 500 units/ml.; but it is possible that these may be reduced on continued investigation.

It was found that quite satisfactory blank determinations could be made in all the above cases and with greater speed by using normal alkali for inactivation of the penicillin, followed by careful neutralization instead of the enzyme procedure proposed by Ford.

A detailed account of this work will be published elsewhere.

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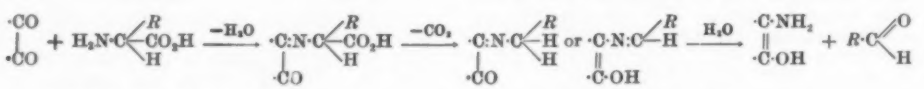
[1] Staab, Ragan and Binkley, Abst. 109th Meeting American Chem. Soc. (1946).
[2] Ford, *Indust. Eng. Chem. (Anal. Ed.)*, **19**, 1004 (1947).

Action of Vitamin K_1 on α-Amino-Acids

The term 'Strecker degradation' has been coined[1] for the degradation of α-amino-acids into aldehydes or ketones containing one less carbon atom by the action of carbonyl groups (for example, phenyl amino-acetic acid → benzaldehyde). Mono-carbonyl compounds are unable to bring about this degradation; at least two carbonyl groups must be present in an agent which can effect it, and the carbonyl groups must be parts in the grouping .CO.(C=C)$_n$.CO. (I), where $n = 0$ or an integer; at least one carbonyl group must be aldehydic or ketonic. The mechanism of the Strecker degradation may be illustrated as follows:



As vitamin K_1 contains grouping (I), it seemed desirable to investigate if it is capable of effecting the Strecker degradation; this is actually the case under physiological conditions of temperature and *p*H, as may be seen from the following example. Vitamin K_1 (0·5 gm.) phenyl amino-acetic acid (1 gm.) and water (50 c.c.) were heated at 38° for 48 hours in a closed vessel filled with carbon dioxide. The reaction mixture was then concentrated under reduced pressure at a temperature not exceeding 38°; the distillate was collected in an alcoholic solution of phenyl hydrazine, when benzaldehyde phenyl hydrazone (0·5 gm.) was formed.

The power of bringing about the Strecker degradation should not be overlooked when the physiological role of vitamin K_1 is considered; 2-methyl-1 : 4-naphthoquinone used in medicine in place of vitamin K_1 is also capable of producing the Strecker degradation.

In this connexion we should like to mention that patulin cannot bring about the Strecker degradation of α-amino-acids (for example, leucine) under physiological conditions, but does so at 100°. This may be explained by assuming that patulin does not contain grouping (I), but is transformed to a substance containing this grouping[2] at 100°.

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[1] Schönberg, Moubasher and Akila Said, *J. Chem. Soc.*, 176 (1948).
[2] Cf. Bergel, Morrison, Moss and Rinderknecht, *J. Chem. Soc.*, 415 (1944).

Significance and Use of Dehydration Effects in the Analysis of Steroids

When various steroids are treated with acid-dehydrating agents, coloured or fluorescent products are often obtained[1]. Such reactions form the basis of many steroid analytical procedures[2].

Miescher[3], in reviewing steroid colour reactions, states that $\Delta^{-16:17}$ androstene, pseudo-androstene and a tricyclic diene are stages in the development of colour produced in the reaction of androstanol-17α with a range of acid reagents. The ease of dehydration to unsaturated derivatives and thence to highly reactive chromogens could conceivably be used to differentiate between pairs of stereoisomeric hydroxylic steroids, and secondary hydroxylic from the corresponding tertiary hydroxylic steroids.

Since very strongly acid-dehydrating conditions are likely to cause similar changes in pairs of isomers, or related steroids, very mild conditions of dehydration in acid media have been sought which will only effect development of colour or fluorescence from those steroids with sterically unhindered hydroxyl or tertiary hydroxyl groups. 90 per cent formic acid[4] has been used as a mild dehydrating agent for steroid tertiary alcohols in synthetic work, and coloured by-products were reported. 98–100 per cent formic acid A.R. at 95° C. has now been investigated as an analytical reagent for some thirty-eight steroids. The results indicate that 1 microgram of 'β'-œstradiol can be estimated fluorimetrically in the presence of 100 μgm. of 'α'-œstradiol. In addition, *cis*-testosterone is readily detected in admixture with *trans*-testosterone. The reactions with other steroids are listed in the table.

Examples of steroid reactions obtained with 98–100 per cent formic acid at 95° C.

Steroid	Colour (visible light)	Fluorescence (ultra-violet light)
'α'-œstradiol	Nil	Faint blue
'β'-œstradiol	Bright pink	Yellow-green (*a*)
16-keto-'α'-œstradiol	Nil	Green-yellow (*a*)
Œstriol	Pink on long heating	Nil
Œstrone and equilin	Not readily soluble in formic acid	
cis-Testosterone	Initially blue, then green-blue	Bright yellow-green (*b*)
trans-Testosterone	Nil	Faint blue-green
Androstanedione 3–17	Nil	Blue
Androstenedione 3–17	Nil	Bright green
Kendall's *E* 17-hydroxy-11-dehydrocorticosterone	Nil	Faint blue-green
Ethisterone	Pale blue-mauve	Bright yellow-green (*c*)
Progesterone	Nil	Faint blue-green
Trans-trans-17 methyl androstenediol 3–17	Pink-mauve	Blue
Trans-17 methyl testosterone	Nil	Bright green

(*a*) Fluorescence is not extracted by benzene.
(*b*) Fluorescence is extracted by benzene.
(*c*) Bright orange fluorescence passes into benzene phase.

Use has been made of the partial immiscibility of benzene with formic acid in order to improve further the specificity of the reaction and to separate some of the interfering coloured and fluorescent reaction products derived from urinary or tissue extracts.

In view of the comparative instability of 'β'-œstradiol in acid solution, the effect of 15 vol. per cent hydrochloric acid—commonly used to hydrolyse urinary œstrogen conjugates—on 'β'-œstradiol and other œstrogens has been followed with the formic acid reagent. 'β'-Œstradiol, but not 'α'-œstradiol, is rapidly converted into an evanescent pink compound with green fluorescence in the presence of 15 vol. per cent hydrochloric acid at boiling point. No pink colour was detected if zinc had been added to the reaction mixture. The product from the acid-treated 'β'-œstradiol, isolated by solvent extraction, reacted immediately with formic acid at room temperature to give a stable pink colour with green fluorescence. It therefore differs from pure 'β'-œstradiol, which requires heating with the acid reagent before colour develops. The zinc-treated 'β'-œstradiol gave no colour with formic acid.

A study of the action of acid-dehydrating agents on stereoisomeric 17-hydroxy-steroids suggests that isolated $\Delta^{16:17}$ urinary steroids may be derived either *in vitro* or *in vivo* from the related steroid possessing a sterically unhindered hydroxylic group.

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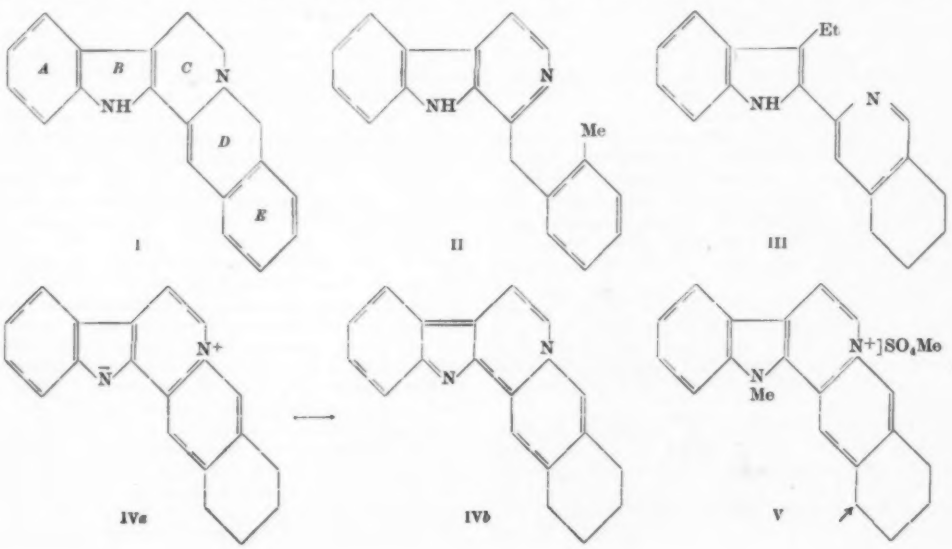
[1] Fieser, L. F., "Chemistry of Products Related to Phenanthrene" (Reinhold Publishing Corp., N.Y., U.S.A.).
[2] Boscott, R. J., *Nature*, **162**, 577 (1948). Carol, J., and Molitor, J. C., *J. Amer. Pharm. Assoc.*, **36**, 208 (1947). Cohen, H., and Bates, R. W., *J. Clin. Endocrinol.*, **7**, 701 (1947). Jaller, J. W., *Endocrinol.*, **41**, 198 (1947). Umberger, E. J., and Curtis, J. M., *J. Biol. Chem.*, **178**, 275 (1949).
[3] Miescher, K., *Experientia*, **2**, 237 (1946).
[4] Inhoffen, H. H., Logermann, W., Hohlweg, W., and Serini, A., *Ber.*, **71**, 1024 (1938).

Structure of Sempervirine

Prelog[1] has proposed the structure (I) for sempervirine, the reddish-brown alkaloid of *Gelsemium sempervirens* (Carolina jasmine), from which he obtained yobyrine (II) by treatment with selenium at 295–300° and "tetrahydroyobyrine" (III) by boiling in xylene with Raney nickel. We are indebted to Dr. G. A. Swan for the information, in advance of publication, that he has synthesized a base having the constitution (I) which is not identical with the alkaloid; unlike sempervirine and like the structurally related dihydroberberine, it can be dehydrogenated to a quaternary iodide by iodine in the presence of sodium acetate.

No modification of the pentacyclic Prelog formula having rings *A* and *E* both unreduced seems now to be acceptable; but if the production of (III) under mild conditions indicates that ring *E* in sempervirine is hydrogenated (as in yohimbine), the alkaloid can only be represented by the expression (IV*a* ⟷ IV*b*) as an 'anhydronium base'. This formula is consistent with the deep colour and great strength of the base ($pK \sim 10{\cdot}6$).

The salts of sempervirine with acids are pale yellow, as is the methosulphate which we formulate as (V). This last shows few of the reactions character-



istic of berberinium salts, which would here destroy the aromatic character of *two* pyridine nuclei; but it reduces alkaline ferricyanide, and gives with nitrosodimethylaniline in presence of piperidine a deep purple product (presumably by condensation at →) which affords dimethyl-*p*-phenylenediamine on acid hydrolysis. Reduction of (V) with zinc and acetic acid gives a non-quaternary methyloctahydrosempervirine, showing that the basic nitrogen atom is doubly linked, unless a C—N bond is ruptured by reduction. This remote possibility has been disproved by effecting the following reactions:

Sempervirine methosulphate	Zn—AcOH	Methyloctahydrosempervirine m.p. 187–189°	→	Methyloctahydrosempervirine benzyloiodide decomp. 230°
Sempervirine benzylobromide	Zn—AcOH	Benzyloctahydrosempervirine (gum)	→	Benzyloctahydrosempervirine methiodide m.p. 255°

The final products are manifestly distinct quaternary salts, and it is clear that both nitrogen atoms are involved in these changes.

The formulation (IV*a* ↔ IV*b*) implies a high electrical dipole moment for sempervirine. Preliminary observations on a dioxan solution of the difficultly soluble base indicated a value approaching 8 *D*, which we report with all reserve. The details of this and further work will be published elsewhere.

We are indebted to the Department of Scientific and Industrial Research for a maintenance grant (to R. B.).

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[1] *Helv. chim. Acta*, **31**, 588 (1948).

Formation of Chelate Complexes between Thiouracils and Heavy-Metal Salts

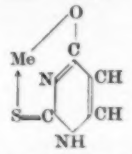
The precipitation of heavy-metal salts by 6-benzylthiouracil in aqueous solution was observed some years ago[1].

We have studied the behaviour of some thiouracils towards salts of metals considered as oligo-elements. Aqueous solutions, saturated at 20°, of the following thiouracils, 6-benzyl-thiouracil (I), 6-phenyl-thiouracil (II), 5,6-trimethylene-thiouracil (III), 5,6-tetramethylene-thiouracil (IV), 6-methyl-thiouracil (V) and 5-benzyl-6-methyl-thiouracil (VI), were successively treated with dilute solutions of the following compounds: cobalt chloride, zinc sulphate, ferrous sulphate, manganese sulphate and copper sulphate. Whereas cobalt chloride gave no precipitation, the remaining salts all gave more or less abundant precipitates: zinc and iron precipitate about 5 per cent of each thiouracil, manganese 10 per cent, copper almost the whole.

In the case of copper, the composition of the precipitates obtained corresponds to the fixation of one copper atom on every thiouracil molecule; that copper is part of a complex and cannot be detected by the usual reagents. The *p*H of the filtrates is distinctly acid.

The speed of formation of thiouracil copper-complexes depends on the nature of the thiouracil involved. Flocculent precipitation is instantaneous with I and II. With III and IV, the solution instantaneously becomes cloudy, but a thorough precipitation requires a couple of hours. With V and VI, there is an instantaneous change of colour (from blue to green); but precipitation only begins after a while and lasts twenty-four hours.

The structure of thiouracils suggests the following formula for the chelate complexes:



Moreover, we observed for 6-methyl-4-thiouracil the same reaction with copper sulphate as with iodine, following Miller, Roblin and Astwood[2]. An aqueous solution of 6-methyl-4-thiouracil added to a solution of copper sulphate instantly modifies its blue colour into olive-brown. No complex is formed. With gentle heating, a brown flocculent precipitate appears after a while. Precipitation proceeds for quite a long time in the strongly acid filtrate. The precipitate obtained at first does not contain either ionic or concealed copper. It behaves like the disulphide described by Miller *et al.* and is partly re-transformed into 6-methyl-4-thiouracil by sodium sulphite. The instability of cuprous sulphate explains why the filtrate continues to produce a precipitate after the disulphide has been removed.

The lack of physiological activity of 4-thiouracils is remarkable. On the other hand, Leloup observed some time ago[3] that administration of active thiouracils to animals reduces cupræmia.

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Montrouge (Seine).

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Oxygen Exchange with Oxides

As yet few exchange reactions between gases and solids have been reported, and it was suggested to us by Dr. J. S. Anderson that a study of the exchange between oxygen gas and metal oxides might be of interest from the point of view of reactions in the solid state. We give here a preliminary account of the exchange results for oxides of copper (CuO), cobalt (Co_3O_4 and CoO) and nickel (NiO).

In brief, the experimental technique used was as follows. The oxide under investigation was formed by oxidation of a thin film of the metal deposited electrolytically on a platinum gauze. The oxygen used in this process contained about 1·4 per cent oxygen-18. The exchange was carried out by passing excess of normal oxygen at a definite pressure (above the dissociation pressure) over the heated oxide. At the end of the reaction period the oxide was reduced with hydrogen, and, from the accurate measurement of the density of the sample of water formed, the percentage exchange could be calculated.

The present work is divided into three sections: (i) investigation of the temperature–percentage exchange relation for the oxides mentioned above (see Fig. 1); (ii) investigation of the time–percentage exchange relation for the oxide Co_3O_4 (see Fig. 2); (iii) investigation of the pressure–percentage exchange

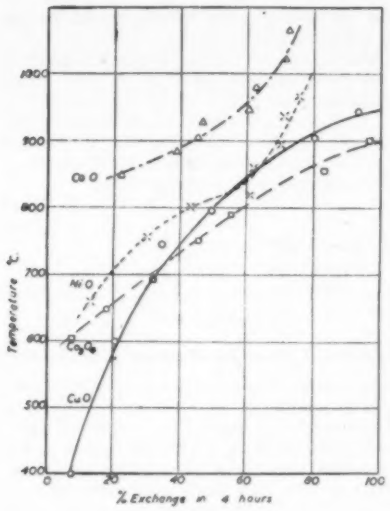

Fig. 1

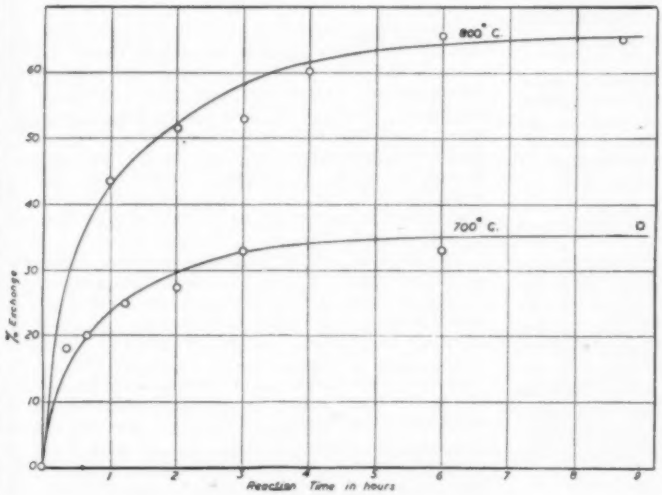

Fig 2

relation for the oxide Co_3O_4 (see accompanying table). Discussion of our results will be reserved for a later publication.

Temperature (° C.)	Pressure (cm. Hg)	% Exchange
650	16·6	16
650	34·0	11
650	76·0	14
700	0·2	37
700	0·2	41
700	1·4	27
708	17·6	46
705	36·8	46
705	76·0	40
805	17·5	53
805	35·0	54
805	76·0	49
880	19·2	90
880	34·6	93
880	76·0	95

We wish to acknowledge helpful discussions with Dr. J. S. Anderson, of the Atomic Energy Research Establishment, Harwell, and also with Dr. J. W. Mitchell, Physics Department, University of Bristol.

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Long-Range Protons from the He^3 (*d*,*p*) α-Reaction

From the known masses of the isotopes helium-3 and deuterium, the energy released in the reaction $He^3 + D^2 = He^4 + H^1$ is calculated to be 18·3 MeV., so that the energy of the emitted protons would be approximately 14·6 MeV. It was considered that an investigation of the energy of the emitted protons might serve to establish whether the α-particle has any excited states below 18·3 MeV., since if the α-particle could be left in excited states the emitted protons would have a number of discrete energy values.

We have carried out an experiment to measure the energies of the protons emitted when a heavy-ice target was bombarded with helium-3, using an accelerator of the Cockcroft and Walton type. The helium-3 ions were produced in a radio-frequency excited ion source supplied with helium, the helium-3 content of which had been enriched to about 4×10^{-3} by thermal diffusion. The canal through which the ions passed from the ion source into the accelerator tube was designed to restrict the consumption of helium to not more than one standard c.c. per hour.

The target assembly consisted essentially of a stout copper rod cooled by liquid air, the upper end being faced at an angle of 45° to the helium-3 beam. A side-tube led to a supply of deuterium oxide to enable heavy ice to be condensed on to the target. Immediately opposite the target was an exit window, about 1 sq. cm. in area, covered with 0·001 in. thick 'Styrafoil'.

An 'end-on' counter with a thin aluminium window was placed close to the 'Styrafoil' window. The counter was used as a proportional counter and was connected via an amplifier and pulse-height discriminator to a scaling circuit. The discriminator bias was adjusted so that protons entering the counter had to be practically at the end of their range in order to give pulses sufficiently large to be recorded. Fast protons could be slowed down by aluminium foils placed before the counter window.

Fig. 1 shows a plot of the counting-rate as a function of the amount of aluminium traversed by the protons. It is seen that there are two groups of protons with ranges of approximately 325 mgm./cm.² (14·6 MeV.) and 21 mgm./cm.² (2·9 MeV.). The second group of protons is identified as the product of a background D—D reaction, due to the fact that the accelerator

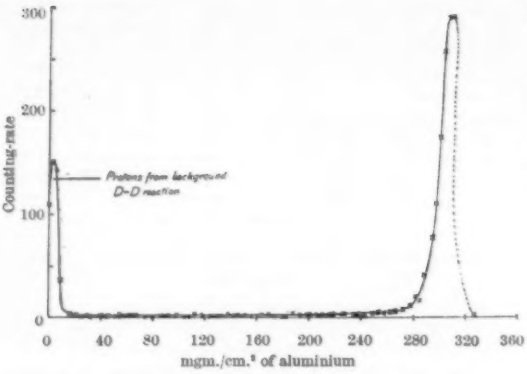

Fig. 1. Counting-rate *vs.* amount of aluminium traversed. Approximately 10 mgm./cm.² should be added to the abscissæ to allow for the windows of the target and counter

had been used for several weeks previously with deuterium ions. This was confirmed by repeating the experiment with deuterium in the ion source. Furthermore, the same low-energy group of protons was present when the ion source was supplied with helium-4, although in this case no long-range protons were found.

The results indicate that in the reaction under consideration there are no low-energy proton groups with an intensity as high as one per cent of the main group having energies greater than 2·9 MeV.

Using helium-3 ions accelerated to an energy of 160 keV., the cross-section for the reaction $He^3 + D^2 = He^4 + H^1$ was estimated to be of the order of one-tenth of that for the D—D reaction at the same bombarding energy.

The number of long-range protons as a function of the bombarding energy was determined over the range 80–180 kV. The results are shown by the crosses in Fig. 2, the solid line being a simple Gamow excitation curve for comparison. It appears that the reaction cross-section in this energy region is determined by the penetrability of the nuclear potential barrier. Extrapolating from our results, it appears that, at an energy of 1 MeV., about 10^7 long-range protons per minute per microamp. of helium-3 ions

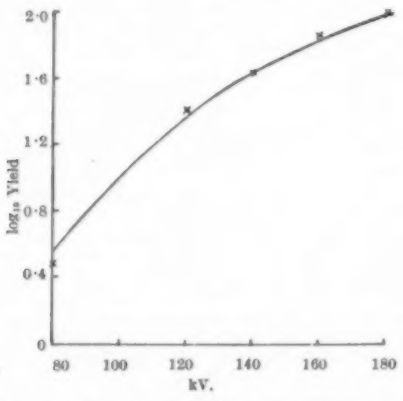

Fig. 2. Yield of fast protons *vs.* bombarding energy of He^3. The solid line is a simple Gamow curve for comparison

incident on a heavy-ice target would be produced over a solid angle of 4π.

We would like to acknowledge the generous help received from several members of the Laboratory, in particular from Mr. C. H. Collie, Dr. D. Roaf and Dr. B. V. Rollin. We are also indebted to Mr. P. A. Davenport, Mr. K. I. Mayne, Mr. F. V. Price and the High Voltage Group, and to Mr. P. C. Thonemann for their assistance at various times.

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Electron Bombardment Conductivity

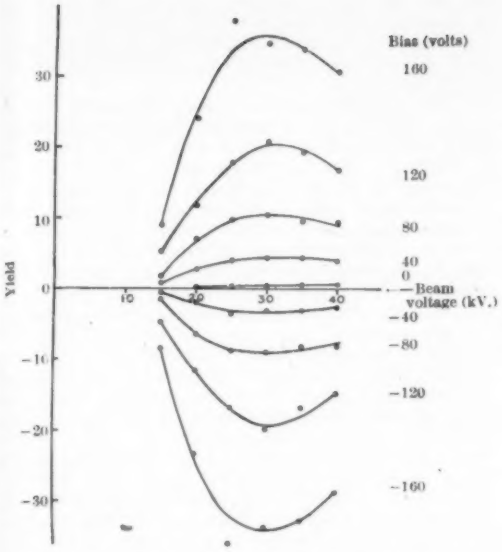
Until very recently the electronic conduction induced in insulators by electron bombardment had received very little attention, in spite of the interest its study must have from the theoretical and possibly also practical points of view. This situation is due probably to the fact that early attempts indicated values of only 10^{-5} to 10^{-4} for the yields, that is, the ratios of the current through the insulator to that bombarding it.

Observations made on cathode ray tube screens[1,2] had led us to believe that these first results cannot possibly tell the whole story, and the more recent discovery of crystal counters has confirmed this suspicion. We have for some years been engaged on experiments on electron bombardment conductivity. The recent publication of work on the same subject, though on different substances and with different techniques[3,4,5], has indicated a sufficient interest in the subject to encourage us to publish now the main results so far obtained.

The majority of our tests were made under D.C. conditions, and, in order to minimize space-charge effects, on very thin dielectric films sandwiched between conducting layers (electrodes). At least one of these electrodes was an evaporated aluminium or gold film just thick enough to ensure electric conductivity. The thickness of the dielectric films was of the order 1 μ. When an electron beam enters the dielectric film normally through the thin metal electrode, a current is observed to pass from one electrode to the other which, under optimum conditions, rises to several thousand times the bombarding current; in general, the yield depends on the voltage of the electron beam and its current density; it increases with a bias voltage applied between the electrodes, and with the temperature of the dielectric.

The preparation of the specimens requires great care; in particular, any flaws in the dielectric film will be shown up by the evaporated electrode and will lead to a premature dielectric breakdown, whereas a mercury droplet, as is often used for breakdown tests, will not penetrate any cracks.[5] Good films show, however, the same breakdown strengths measured either way. Successful films were obtained of mica (split), glass (blown), aluminium oxide (grown on pure aluminium sheet), arsenic oxide (As_2O_3, evaporated, amorphous), antimony sulphide (Sb_2S_3, evaporated, crystalline). Only on the last three substances were yields exceeding unity observed at temperatures at which the ionic conduction was still small.

A typical family of curves showing yields *vs.* beam voltages is shown in the accompanying graph.



As_2S_3 film 2 μ thick; $T = 290°$ K. and current density 0·25 microamp./cm.^{2}. Gold electrodes

The direction of flow of the primary electrons is taken as positive; the bias is called positive if it accelerates electrons in this direction. The current across the dielectric starts at a critical beam voltage, at which some of the primary electrons just penetrate the film. The maximum appears to be associated with a voltage at which the majority of electrons just spend their range within the film. The difference between positive and negative yield is of the order of unity. The yield increases with bias nearly quadratically, and above room temperature very fast with temperature. On an arsenic sulphide film 1·6 μ thick the following yields were observed with a beam current of 0·25 μ amp./cm.^{2} at 25 kV. with + 50 V. bias.

$T = 90°$ K., $y = 2·4$. $T = 290°$ K., $y = 8·5$. $T = 420°$ K., $y = 1{,}000$

These figures indicate that, in the language of the trap theory, a yield of the order unity arises through the mobility of the secondary electrons and holes released within the dielectric by the primary beam, and their life as conduction electrons before their recombination or before being trapped; whereas at elevated temperature the thermal release of trapped electrons comes into play.

In the tests quoted, one may expect one primary electron to create at least 2,000 pairs of holes and electrons, so that their mean displacement for unit yield comes to at most 10^{-7} cm. If one assumes a mobility of the order of 100 cm.^{2}/volt/sec., these 10^{-7} cm. will be traversed with a velocity of 3×10^7 cm./sec. in less than 10^{-14} sec. At elevated temperatures the large current across the film results from the thermal release of the trapped charges. There will be an equilibrium between their transport under the influence of the applied field and the re-establishment of trapped electrons and holes by the primary beam and an associated space charge.

For very high temperatures and strong fields, the yield should approach the initial ratio of pairs to primary electrons, and in the example quoted the yield has reached less than half this limiting value. At a given temperature and bias the yield decreases with increasing beam current density, presumably due to space-charge effects (saturation).

The experiments with aluminium oxide and with antimony sulphide films give qualitatively the same results, though the maximum yields are smaller. In particular, crystalline antimony sulphide behaves not very differently from the amorphous arsenic sulphide.

Only tentative experiments with pulsed electron beams have so far been made. The high capacity of the specimens makes observations at high frequencies difficult. So far we have observed no time-lag in the rise of secondary current. If, however, the bias voltage is suddenly reversed, the initial yield at high temperature starts at a value several times lower than the stationary yield discussed above, and rises to it in a few seconds.

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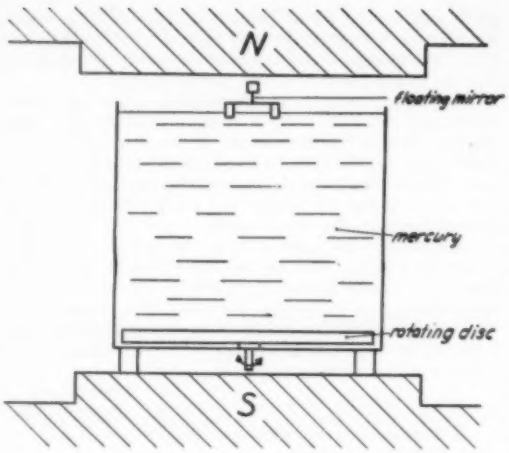
Experimental Demonstration of Magneto-hydrodynamic Waves

In an electrically conducting liquid placed in a magnetic field, there is a mutual interaction between electromagnetic and hydrodynamic forces. Alfvén[1] has shown that this interaction may cause a new type of waves, called magneto-hydrodynamic waves, which travel in the liquid in the direction of the outer magnetic field, carrying an induced magnetic field as well as a velocity field with them. It seems probable that they are of great importance in solar physics, especially for the theory of sunspots. They may be important also in other branches of cosmical physics. They have not hitherto been observed in the laboratory; but an experimental investigation is very desirable, especially as many problems connected with waves are very difficult to treat theoretically.

Due to the finite conductivity, the waves are damped very much under laboratory conditions, even in such a good conductor as mercury, and this makes it difficult to demonstrate the waves. The damping is decreased if the magnetic field is increased. Calculations show that it should be possible to observe the waves in mercury, subject to a magnetic field of the order of 10,000 gauss.

In the experiment, the mercury is enclosed in a cylindrical vessel with the axis parallel to a strong vertical magnetic field (see diagram). The diameter of the vessel is 15 cm. and the height is about 13 cm. The waves are excited mechanically by the rotational vibrations of a disk near the bottom of the cylinder. The tangential velocity, v, of the mercury at the bottom may thus be written $v = v_R \cdot \frac{r}{R}$, where v_R is the velocity at $r = R$, the radius of the cylinder. For the theoretical calculations this expression for v should be split up into a series of Bessel functions,



such that $v = \Sigma A_\nu J_1(k_\nu r)$, the wave-numbers k_ν being defined by $J_1(k_\nu R) = 0$. The waves corresponding to each term of this series are transported to the free surface of the mercury and are reflected there. Due to the finite conductivity, the damping and the wave velocity are different for different wave-numbers, causing a distortion of the wave.

A measuring device consisting of a small mirror floating on the surface is used for indicating the angular displacement. The mercury must be very clean, because the slightest trace of dirt at the surface brakes the motion of the mirror. Preliminary measurements of the damping and the phase-difference show a satisfactory agreement with the theoretical values. The frequencies used are 0·1–1 sec.$^{-1}$, and the outside magnetic field is about 10^4 gauss. The amplitude is damped to about 50 per cent and the phase-difference between top and bottom varies from 10° to 100°. A detailed report will be given later.

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Luminescence of Silver Halides at Low Temperatures

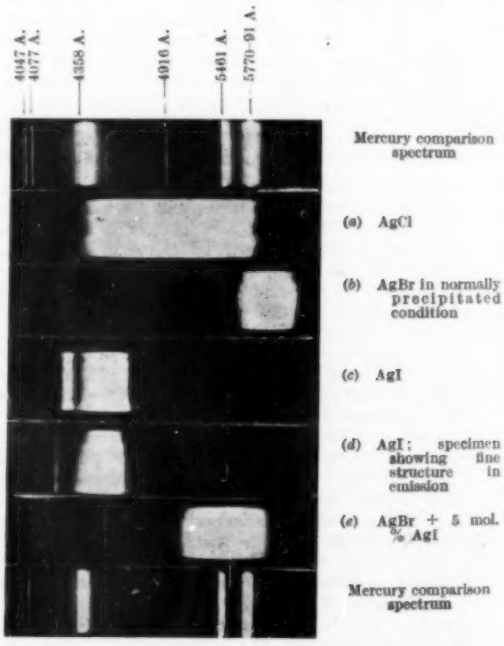
RANDALL[1] has reported that silver chloride shows a bright blue-green fluorescence at 85° K., while Meidinger[2] has described the low-temperature fluorescence of gelatin layers containing silver chloride, bromide, iodide and bromo-iodide. The latter's results were of direct photographic interest; but the influence of gelatin and other emulsion impurities was not ascertained. In the work to be described, the silver halide specimens were studied in the absence of known impurities.

Precipitated specimens of silver chloride, bromide, iodide and mixed crystals in various proportions were made from analytical reagent, or purer, solutions (preparation and handling in red light). They showed no room-temperature luminescence, and no visible phosphorescence or thermal afterglow between 20° K. and 290° K. The specimens were excited at 85° K. by mercury wave-lengths in the range 3130–4047 A. (excitation by shorter wave-lengths gave the same results). No noticeable photolysis occurred at the low temperature.

Silver chloride gave a strong blue-green fluorescence with a broad structureless spectrum extending from 4300 to 5800 A. (spectrum *a*). The emission was probably not due to foreign metal ions or minute quantities of metal impurities, for specimens precipitated from eleven different metal chlorides and several specimens of silver nitrate gave identical spectra. Additions of various metal chlorides to the melt in concentrations less than 5 mol. per cent had practically no effect. To eliminate the possibility that free silver or structural defects were responsible for the emission, large crystals of silver chloride grown in ammonia were annealed for five hours at 400° C. in an atmosphere of chlorine. The emission characteristics remained unaltered, except that the specimens were even more strongly fluorescent than before the annealing treatment.

Precipitates of silver bromide at 85° K. possessed a faint orange-red fluorescence (band 5700–6500 A.; spectrum *b*), which was ascribed to the presence of silver, since it could be eliminated by first melting the bromide in a bromine atmosphere, the bromided specimen so obtained being re-activated by allowing it to print out at ordinary temperatures for a few seconds. At 20° K., however, silver bromide showed a very strong green fluorescence (band 4700–5400 A.), which we consider to be the characteristic emission of the pure solid. We are indebted to Prof. F. E. Simon, of the Clarendon Laboratory, Oxford, for the facilities and use of liquid hydrogen for this observation.

Silver iodide shows a blue-violet fluorescence. The spectrum consists of a rather narrow band with a



Fluorescence emission spectra of various silver halide specimens

peak at 4500 A., and a much narrower band at about 4270 A., which sometimes shows a fine structure (spectra *c* and *d*). At ordinary temperatures, silver iodide is precipitated as a mixture of the zinc blende and wurtzite crystal structures, and slight differences in the emission structure of various specimens have been found to be due to varying proportions of the two structures. The composition of the specimens was determined by X-ray analysis, for which we are indebted to Mr. A. H. Fox of these Laboratories.

Precipitated mixed crystals of the three pairs of silver halides have also been investigated in some detail. From a knowledge of the emission of the pure halides and the extents of mixed crystal formation between them it was possible to interpret all the results obtained.

Bromo-iodide mixed crystals formed a particularly interesting case. Inclusion of a small amount of silver iodide (~0·01 mol. per cent) in silver bromide was sufficient to induce the emission of a narrow green band, which increased in intensity up to a silver iodide content of 5 mol. per cent (spectrum *e*). From this point the emission intensity decreased slowly as the silver iodide content was raised to 30 mol. per cent (beyond this point silver iodide begins to precipitate out as a separate phase), then fell more rapidly until it had disappeared at 60 mol. per cent silver iodide. At the same time, the emission of pure silver iodide increased in intensity.

The green emission band appears to be due to the iodide ion, its spectral emission being displaced compared with silver iodide owing to the different crystal environment. This was confirmed by the fact that thallium iodide (non-fluorescent at 85° K.) containing 5 mol. per cent silver iodide showed a strong narrow yellow emission band.

The fact that we obtained essentially the same emission spectrum for pure bromo-iodide mixed crystals as did Meidinger with bromo-iodide emulsions shows that the luminescence cannot be explained in terms of silver sulphide specks acting as impurity centres, as has been attempted by Vassy and Vassy[3].

It is hoped that a full account of the investigation will be published elsewhere.

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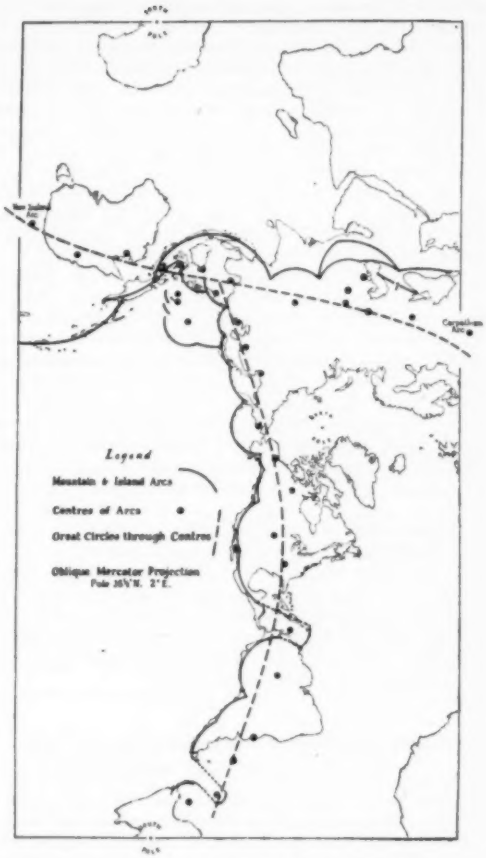
An Extension of Lake's Hypothesis Concerning Mountain and Island Arcs

In 1903, W. J. Sollas[1] pointed out that many mountain and island arcs are truly circular and that in some cases the poles or centres of several arcs lie upon the same great circle. In 1931, Philip Lake[2] clarified the idea, showing in particular that the poles of the east Asiatic island festoons and those of the mountain arcs of southern Asia lie very well upon two great circles which intersect at the pole of the main arc of the Netherlands East Indies.

It has recently been noticed that Lake's observations about these arcs may be extended; that, in fact, the poles of the island and mountain arcs formed



Post-Triassic mountain and island arcs, their poles and the great circles through these poles upon an oblique mercator projection with its pole at 35½° N., 2° E. (after A. R. Hinks). The New Zealand–New Caledonia arc, the New Zealand–Tonga arc and the European arcs, which are irregular, lie off this map

from the Jurassic period to the present lie fairly well upon the continuations of the same two great circles. This is shown in the accompanying map, to which the two great circles which best fit the poles have been added by means of the proper graticule. The map was drawn upon an oblique mercator projection due to A. R. Hinks[3], which emphasizes the *T*-shape of the approximately orthogonal intersection.

Irregularities occur wherever two continents approach closely. They are particularly marked in the Mediterranean region, which has, however, the proper general trend. Elsewhere the symmetry is surprisingly good. Four remarkable features are that adjacent arcs in general join one another; that arcs do not usually cut great circles; that the poles lie equally well on the great circles, regardless of upon which side the arcs lie (note the North and South Antilles); and that from Burma through the Netherlands East Indies to New Guinea the grandest arc of all caps the junction.

This simple rule relates the position and shapes of the young orogenic belts, which are also the principal volcanic and seismic regions. It can scarcely be fortuitous, and it suggests that there may be some simple explanation. If this can be found, it is likely

to have a fundamental and profound bearing upon many aspects of geology.

The only explanation so far offered is that of Lake, who explained the remarkable symmetry which he had discovered by suggesting that the arcs are the outcrops of thrust planes which "are all at right angles to the plane of the great circle" which passes through their poles. He also suggested that Asia was being underthrust by the ocean floor from both sides, and that this might be a consequence of the contraction theory[4]. For the rest of the arcs it can also be seen to be true that the thrust planes postulated would dip towards the nearest continent.

Because Lake's hypothesis satisfies some features it is not, therefore, necessarily the correct one, or the only possible explanation; but it deserves detailed examination, comparison with other explanations of the earth's surface features, and consideration of the extent to which it can, with modification, explain known features.

I wish to acknowledge that this observation was made while engaged upon research supported by the Research Council of Ontario; I would like to thank Dr. E. C. Bullard for reading the manuscript.

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Constant-Stress Measurements of the Hardening of Soft Materials

The use of sphere indentation hardness tests is by no means confined to metals, experiments having been reported on pitch and 'Plasticine'[1], plastics[2,3], rubber[4] and cheese[5], and in some of these investigations the relationship between depth of indentation (Δ) and load has been studied.

In our work on hard-pressed cheese, we have investigated the effect of a progressive increase in load on depth of indentation; but factorial analysis[6] showed that the method first used, in which the load was increased by stages, did not measure 'hardening', and the test was therefore re-designed.

We have now constructed a machine in which a weight, drawn at a steady rate along a beam, progressively increases the load on the indenting sphere. Following the application of the initial load and the rapid fall in stress which occurs when the sphere begins to penetrate the material, it is easy to arrange that the rate of increase of load shall eventually just compensate for the increase in area of contact between sphere and material; so that the stress remains virtually constant for any batch of samples of comparable hardness.

Should part of the deformation be elastic, the extent of recovery can be measured, after the removal of the load, in the usual way.

The accompanying table shows values of Δ, time after application of initial load (t) and stress (S) for two samples of cheese. The relationship between Δ and t is generally of the form $\log \Delta = a + b \log t$, so long as S is constant.

Cheese 1						
Δ (cm.)	0·354	0·395	0·430	0·462	0·482	0·500
t (sec.)	10	20	30	40	50	60
S (kgm./cm.^{2})	1·04	1·01	0·98	0·97	0·99	1·01
Cheese 2						
Δ (cm.)	0·448	0·513	0·562	0·602	0·633	0·660
t (sec.)	10	20	30	40	50	60
S (kgm./cm.^{2})	0·82	0·77	0·75	0·75	0·75	0·76

It is hoped that this very simple method of measuring the deceleration of rate of indentation by a sphere at constant stress may prove useful for quite a number of soft materials.

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Gravitational Field of a Particle

The usual exterior Schwarzschild line element shows an obvious singularity for a certain value of r, say $r = a$. Since a is in every known case much smaller than the radius of the spherical body producing the field, the existence of the singularity appears to be of little interest to astronomers. At the other end of the scale, a discussion of the gravitational field of an ultimate particle, without reference to electromagnetism or quantum theory, might appear equally devoid of physical meaning.

Nevertheless, it does not seem right to leave the theory of the gravitational field of a particle (I mean a *point*-mass) uncompleted merely because there is no direct physical application. The existence of the singularity at $r = a$ is strange and demands investigation. Investigation shows that there is no singularity at $r = a$; the apparent singularity in the Schwarzschild line element is due to the co-ordinates employed and may be removed by a transformation, so that there remains no singularity except at $r = 0$. This was pointed out by Lemaître in 1933 [1]. The singularity may be removed in other ways also, and I have obtained another transformation which is more complicated than Lemaître's but which seems to have certain advantages over his. I think that the fact that the Schwarzschild line element can be transformed so as to yield the gravitational field of a particle deserves to be more widely known than appears to be the case.

But there is a curious point worthy of note. In both Lemaître's solution and in mine, a test-particle (time-like geodesic) reaches the central particle in finite proper time, and arrives with the velocity of light. This is what we would expect, for we are accustomed to find an infinite Newtonian velocity changed into the velocity of light in relativity. But the implication of this is strange, as we shall now see.

At an ordinary point of space-time there is a null-cone which divides the neighbouring region of space-time into three parts, accessible to one another only by crossing the cone. Two of these parts (the 'future' and the 'past') are composed of time-like directions, and the third part is composed of space-like directions. At the central particle there can be no time-like directions; for if there were, a test particle could arrive along any one of them with a velocity less than that of light, and that is not possible. Thus, at the central particle, the null-cone is singular;

it closes up into a single null-line, the element of this null-line representing part of the history of a test particle arriving with the velocity of light to collide with the central particle. Except for this single null-direction, every direction at the central particle is space-like, and so corresponds to motion with velocity greater than that of light. This applies to the direction of the world line of the central particle itself, and so we are led to the unexpected conclusion that *a particle which exerts a gravitational field must travel faster than light.* This conclusion, it will be noted, is independent of the analytic details of Lemaître's solution or mine; it depends only on the fact that every test particle arrives at the central particle with the velocity of light.

In the above description I have used the word 'velocity' and other phrases convenient but dangerous in general relativity. But the fact remains that there is something queer about a gravitating particle; it seems worthy of further study.

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Feb. 4.

[1] *Ann. Soc. Sci. Bruz.*, A, **53**, 51 (1933), in particular p. 82; I am indebted to Prof. G. C. McVittie for this reference.

Precise Solution of Partial Differential Equations by Resistance Networks

METHODS for the solution of the partial differential equations of physics and engineering through electrical network analogues have been proposed by G. Kron[1] and other authors. A condenser-inductance network for the solution of Maxwell's field equations in wave-guide systems was recently constructed by Spangenberg and Walters[2], and smaller-scale resistance networks were employed by Redshaw[3] for the solution of Poisson's equation and by de Packh[4] for the approximate solution of Laplace's equation. Such analogue methods apparently did not come into more general use because the accuracy of the solutions obtained with their help has so far been of the order of 1–5 per cent only, comparing unfavourably with the available numerical methods, for example, Southwell's[5] relaxation method.

A fresh examination of the properties of resistance networks led me to believe that they should be capable of giving much more accurate results. In a resistor network of 60 × 20 meshes constructed later, where the resistance values were graded to represent the case of axial symmetry, an average accuracy of about 1–2 parts in 10,000 was reached in the solution of Laplace's equation,

$$\nabla^2 f(r,z) = 0, \qquad (1)$$

for given boundary values; the accuracy was checked by setting up several problems for which a rigorous answer could be found. Larger errors, of the order of 3–5 parts in 10,000, due to network faults, were few and localized, lending themselves to a rapid elimination by 'relaxation'. The time taken to obtain a solution to four-figure accuracy with the resistance network is about one-tenth of that required by 'relaxation'. In the same way it was proved that curved boundaries can be easily represented by shunting the network resistors externally, and that measurements at points located *within* a mesh can be taken to a position accuracy of 0·02 mesh-length with the help of a special potentiometer arrangement. Varied boundary potentials or boundary gradients can be established by feeding in currents from an external source at the boundary points. An accurate solution of the more general equation

$$\mathrm{div}(\varepsilon \,\mathrm{grad}\, f) = 0, \qquad (2)$$

representing, for example, the presence of a dielectric in an electric field, can be obtained by making appropriate modifications to the network.

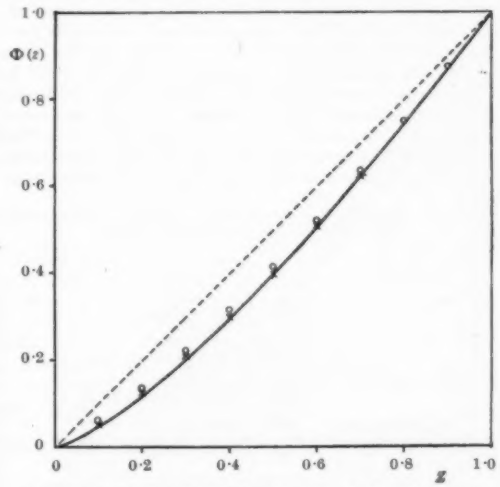
A considerable extension of the range of problems which can be attacked successfully is achieved by feeding in currents of exactly measured values at certain mesh points, combined with an iteration process.

Equations of the type

$$\nabla^2 f(r,z,p) = g(f,r,z,p) \qquad (3)$$

are solved by first obtaining a solution of the equation $\nabla^2 f_1(r,z) = g(f_0,r,z,p_0)$, where f_0 and p_0 are, respectively, arbitrary initial values of the function required, $f = f(r,z,p)$, and of the parameter p, which may be given or sought. This solution yields values of $f_1(r,z)$ and p_1, which are better approximations to the correct values of f and p than f_0 and p_0. Insertion of f_1 and p_1 into the equation $\nabla^2 f_1$ by resetting the values of the fed-in currents gives still better approximations f_2 and p_2, and so on. In all cases investigated so far this iteration process has shown itself strongly convergent and leading to the correct answer with a high degree of accuracy. As an example, the accompanying graph shows the solution of the space-charge problem in a plane diode, described by the (normalized) equation $\nabla^2\varphi = \frac{4}{9}\varphi^{-1/2}$. The dashed line is the solution of $\nabla^2\varphi = 0$, taken as initial values for the iteration process. The circled points are the measured potential values after the first iteration; the crosses denote the measured values after the second iteration. The deviations from the exact curve (full line) of the values obtained in the third iteration are far too small to be represented graphically.

The experimental iteration method has also been applied to 'eigenvalue' problems; for example, the



Normalized potential distribution in plane diode under space-charge condition

solution of Maxwell's field equations for cavity resonators. Various *TE* and *TM* modes of a cavity resonator have been analysed, and the electric and magnetic field distributions and the resonance wavelength obtained to an accuracy of 0·3 per cent. Only a limited number of current feeding points was available, and it is thought that an increase of their number would lead to still higher accuracy.

While the problems to which the resistor network analyser has been applied in this Laboratory so far were mainly taken from electrostatics or electrodynamics and particularly electron optics, it is obvious that the high accuracy, speed of operation and versatility of the method described should have many applications in other branches of physics and engineering. A description of the apparatus and of the methods of measurement and evaluation, and some of the present results, will be published elsewhere.

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Feb. 3.

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Origin of Bacterial Variants

NUMEROUS bacterial variants are known which will grow in environments unfavourable to the parent strain, and to explain their occurrence two conflicting hypotheses have been advanced. The first assumes that the particular environment produces the observed change in some of the bacteria exposed to it, whereas the second assumes that the variants arise spontaneously during growth under normal conditions, the part played by the adverse environment being purely selective. These are known respectively as the 'adaptation' and the 'spontaneous mutation' hypotheses.

In order to discriminate between them an experimental approach (the 'fluctuation test') was developed by Luria and Delbrück in 1943 [1]. This test has been applied to a number of variants, some of them in widely separated strains of bacteria (see Table 1), and in each case the conclusion reached has been that the variant arose by spontaneous mutation. The validity of the fluctuation test has not been challenged, at least so far as I am aware; but on the other hand it has gained only limited recognition (see ref. 2). In part this may be due to the statistical and essentially indirect nature of the argument on which it is based, and if so the more direct experimental evidence described below would seem to be of value.

Table 1. Bacterial variations shown by means of the fluctuation test to arise through spontaneous mutation

Organism	Variation to	Reference
E. coli	phage *T*1 resistance	1, 6, 5
	phage *T*3–*T*7 resistance	6
	radiation resistance	7
	histidine independence	8
	streptomycin resistance and dependence	9, 10
Staph. aureus	penicillin resistance	11
	sulphathiazole resistance	12
	streptomycin resistance	13
Clostridium septicum	uracil independence	14
Hæmophilus influenzæ	streptomycin resistance	15
Eberthella typhosa	tryptophan independence	16
See also data from :		
E. coli-mutabile	lactose fermentation	17
Salmonella	fermentation variants	18

Bacteria of *Escherichia coli* strain *B/r* susceptible to phage *T*1 were plated on agar and incubated until a limited population increase had taken place. On alternate plates the bacteria were redistributed over the surface of the agar by spreading with 0·1 c.c. of sterile saline. All were then sprayed with phage *T*1, and counts made of the colonies of resistant survivors which developed after further incubation. (For details of the spray technique, see refs. 3, 4, 5.)

On the adaptation hypothesis, the bacteria present at the end of the initial growth-period would all be phage-susceptible, and spreading would serve only to redistribute the members of a homogeneous population. No striking differences in colony count between *spread* and *unspread* plates would therefore be expected.

On the alternative (spontaneous mutation) hypothesis, both susceptible and resistant cells would be present at the end of the initial growth-period wherever a sufficient end-population had been reached. Further, mutations taking place a generation or more before the cessation of growth would each be represented by a minute cluster of resistant cells all descended from the one original mutant. Where the arrangement of the bacteria is left undisturbed, a cluster would give rise to a single resistant colony after the application of phage; but where the bacteria are redistributed over the surface of the agar by spreading, a colony would develop from each resistant cell. Higher counts would thus be expected from the *spread* than from the *unspread* plates. This is, in fact, what was found (see Table 2), the difference being as much as fifty-fold where the end population was highest.

Table 2. Resistant colonies developing after spraying agar plate cultures of *E. coli* with phage *T*1, showing the effect of redistribution by spreading prior to spraying

Incub. (hr.)	3		4		5		6	
Bact. plated	$5{\cdot}1 \times 10^4$		$5{\cdot}1 \times 10^4$		$5{\cdot}1 \times 10^4$		$5{\cdot}1 \times 10^4$	
End No. bact.*	$1{\cdot}7 \times 10^8$		$2{\cdot}3 \times 10^7$		$2{\cdot}6 \times 10^8$		$2{\cdot}8 \times 10^8$	
Factor increase	33		480		5,100		54,900	
Resist. colonies	unsp.	sp.	unsp.	sp.	unsp.	sp.	unsp.	sp.
replicate test 1	0	0	0	0	5	194	46	2,254
2	0	0	3	0	3	14	25	1,434
3	0	1	0	6	4	16	45	3,294
4	0	0	2	0	8	13	49	3,719
5	0	0	1	0	2	4	26	1,538
6	0	1	2	2	6	112	49	399
Total	0	2	8	8	28	353	240	12,638

* Estimated by washing and assay; averages of three independent determinations. unsp. = unspread; sp. = spread.

It might be suggested that the bacteria are less likely to become 'adapted' when crowded together in the developing colonies. If this were true, the proportion of bacteria becoming 'adapted' should be least where microcolony size is greatest. Table 2 shows that the average number of bacteria per microcolony at the time of spraying rose with increasing period of incubation from 33 up to 54,900, but that there was no corresponding decline in the proportion of resistant colonies to bacteria sprayed. Thus, crowding cannot account for the lower colony counts from unspread plates.

This experiment, therefore, confirms the conclusion drawn from the fluctuation test, namely, that phage-

resistant variants arise by spontaneous change prior to contact with phage.

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Chalk River, Ontario. Jan. 7.

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Psychological Frequency-Distribution of Holding Times, etc.

THE well-known exponential frequency-distribution of holding times, etc., has probability density

$$p(t) = \frac{1}{T} \exp(-t/T), \qquad (1)$$

and the proportion of completed holds having length at least t is

$$p(> t) = 1 - p(< t) = \exp(-t/T), \qquad (2)$$

where T is the mean holding time. Hence the probability that any individual hold, of present duration t, will end between t and $t + dt$ is

$$\frac{p(t)\,dt}{p(> t)} = \frac{dt}{T},$$

which is independent of t.

In a distribution with probability density

$$p(t) = \frac{1}{M(1 + t/M)^2} \qquad (3)$$

the proportion of completed holds having length at least t is

$$p(> t) = 1 - p(< t) = \frac{1}{1 + t/M}, \qquad (4)$$

and M is the median holding time. Thus the probability that any individual hold, of present duration t, will end between t and $t + dt$ is

$$\frac{p(t)\,dt}{p(> t)} = \frac{dt}{M(1 + t/M)} = \frac{dt}{M}\, p(> t), \qquad (5)$$

which is proportional to the initial chance (4) that the hold had of attaining a length at least t. The longer the hold becomes, the more likely it is to continue.

The new distribution represented by (3) and (4), of which the mean holding time is infinite, bears a modified logarithmic relationship to the exponential distribution represented by (1) and (2). Like the latter, it is easy to manipulate and has a direct physical interpretation (5). It is applicable to problems of operations research where human factors are paramount, as, for example, problems of delay not attributable to machines.

The empirical logarithmic version of the normal distribution

$$p(> t) = 1 - p(< t) = 1 - I$$
$$= 1 - \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} \exp(-u^2/2)\, du, \qquad (6)$$

where $x = \ln(t/Q)/\sigma$, coincides with the distribution (4) when $Q = M$ and

$$\sigma = \frac{1}{x} \ln \frac{I}{1 - I},$$

or, from the probability-density equations,

$$\sigma = \frac{2 + \exp(\sigma x) + \exp(-\sigma x)}{\exp(x^2/2)\sqrt{2\pi}}.$$

Over an important range of values of x the required value of σ does not vary much from $4/\sqrt{2\pi}$, and a suitable figure is $\sigma = 1{\cdot}6$ to $1{\cdot}7$. In the range $x = -1{\cdot}0$ to $+1{\cdot}0$, for example, with $\sigma = 1{\cdot}65$ throughout, t/Q or t/M varies from about $0{\cdot}19$ to $5{\cdot}25$ and $p(< t)$ varies from about $0{\cdot}16$ to $0{\cdot}84$; but the proportionate difference between numerical values of $p(< t)$—or, conversely, of t—computed respectively from (4) and (6) is always less than 2 per cent.

If we assume 100 observations divided into 10 groups, coinciding with the logarithmic normal curve (with $\sigma = 1{\cdot}65$) and distributed over the complete range $t = 0$ to ∞, then on comparison with the distribution (4) it is found that χ^2 has the very small value $0{\cdot}313$ for the differences in $p(< t)$.

Consequently, data which are found empirically to approximate to the logarithmic normal distribution (6), in the conditions stated above, may fit as well or better in the new distribution represented by (3) and (4).

BLICK CRAWLEY
Sevenoaks, Kent. Feb. 2.

Tables of Vapour Pressure of Liquid Helium

THE usual method of measuring absolute temperature T in the liquid-helium range is to measure the vapour pressure p of the liquid-helium bath and convert it by means of an empirically determined p—T relation. In the past, confusion has sometimes arisen owing to the existence of several determinations of the p—T relation which differ appreciably from each other; at an informal meeting between representatives of cryogenic laboratories in Holland, the United States and Great Britain held in Amsterdam in July 1948, it was decided to use an agreed relation in future, and to present this relation in the form of tables for practical use. The most reliable existing data are not wholly satisfactory; but since they are unlikely to be superseded for some years, it was thought best to make them the basis of the agreed relation until more accurate results are available. Tables have been prepared presenting p as a function of T, and T as a function of p, prefaced by a statement about the data on which they are based. Copies of the tables may be obtained on application to the Royal Society Mond Laboratory, Free School Lane, Cambridge.

H. VAN DIJK
Kamerlingh Onnes Laboratory, Leyden.
D. SHOENBERG
Royal Society Mond Laboratory,
Cambridge. June 4.

LABORATORY FOR GEOLOGY AND MINERALOGY AT OXFORD

ON February 9, 1937, the University of Oxford launched a world-wide appeal for money for a number of major projects, mostly for urgently needed science buildings, and among these was a Department of Geology. The situation at that time was such that the writer of an article in *Oxford*[1], the journal of the Oxford Society, suggested that "one cannot in decency ask the new professor (not yet appointed) to take over the cramped quarters in the Museum where geology is now housed, however tolerable his predecessor may have found them".

In response to this appeal, the Shell Petroleum Company made the very substantial contribution of £25,000 towards the cost of a new building, and plans were drawn up for a new department which would replace the Clarendon Laboratory on the north-west flank of the University Museum as soon as Prof. Lindemann (now Lord Cherwell) had transferred his Department of Physics to a new building. This essential move was scarcely completed when war came, and for the time being all further activity was postponed.

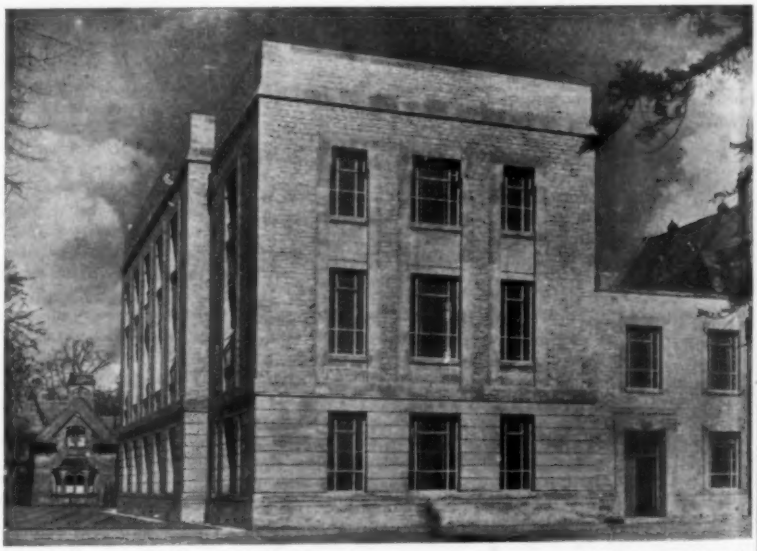
As soon as the War ended, the plans were taken up again; some modifications were necessary when it was decided that the Department of Mineralogy should also be transferred to the new building. It was largely due to the enthusiasm and energy of Prof. J. A. Douglas, head of the Department, that work began so soon after the end of the War, so that the new Department of Geology and Mineralogy is thus the first science building to be completed in Oxford in the post-war period. With the very large increase in the numbers of undergraduates reading geology in the past four years, conditions for teaching in the old laboratory in the Museum became well-nigh intolerable, and there has been a gradual transference to the new building as it became available, beginning with temporary laboratory accommodation in the workshops.

The building was formally opened on July 7 by the Vice-Chancellor of the University, the Very Rev. A. J. Lowe, dean of Christ Church. Besides members of the University, numerous geologists, mineralogists and representatives of the oil-producing companies were present at the ceremony. After speeches by the Vice-Chancellor, by Mr. J. W. Platt, managing director of the Shell Petroleum Company, and by Prof. Douglas, the company was conducted around an exhibition of oilfield development which has been arranged within the Department by a committee representing the major producing companies of the British oil industry (see p. 153).

The new Department consists partly of a new building of three stories and partly of a reconstruction of the Clarendon Laboratory. The new section, which is 103 ft. in length and 35 ft. wide, forms the west side of the Department and faces Keble College. To first-floor level the external walls are faced with tooled ashlar of Clipsham stone from the Inferior Oolite, and above this, punch-faced walling of Bladon stone from Bladon near Woodstock from the Forest Marble formation is used with Clipsham dressings. The floors and flat roof are of reinforced concrete hollow-tile construction, and the floors are covered with Southern Rhodesian teak blocks. The accommodation in this section consists of two large teaching laboratories on ground- and first-floor, a small library in which are displayed manuscripts and original maps of William Smith and other historical material, and also on the first floor the professor's room and private laboratory. The top-floor is given over to the lecturers' private research rooms and to photographic rooms.

The reconstructed portion still retains the central hall and original staircase of the old Clarendon Laboratory. The main entrance has been placed on the south side and the whole of this front refaced with Bladon and Clipsham stone. On the north side of this section of the building are the petrological and chemical laboratories on the ground floor. Above these are the rooms occupied by the reader in mineralogy, Mr. R. C. Spiller. Here, there is a teaching laboratory which can also be used as a lecture room, a physical laboratory, lecturers' rooms and the Herbert Lister Bowman Library containing the valuable library of the late professor of mineralogy, presented to the Department, together with an endowment fund of £1,000, by his widow.

The large lecture theatre of the Clarendon Laboratory occupying the east side of the block of buildings has been taken over and remains in its original



Shell Photographic Unit

New Geological Laboratory at Oxford

form externally. Certain modifications have been made internally; but it is expected that eventually a properly equipped lecture theatre of modern design will be built on this site.

The workshops are single-story rooms adjacent to the main structure and are equipped for rock and mineral sectioning and polishing. There are extensive cellars below the reconstructed building and they are being used for storage. In them was done perhaps the best-known research work in the old Clarendon, namely, Vernon Boys's classic determination of the gravitation constant.

It will be a source of great satisfaction to Prof. Douglas that the transfer of the Department has been carried through during his tenure of the chair in spite of the interruption of the War and the great pressure on building since then. Not only will he eventually leave his successor a spacious teaching department, but also he is now able to accommodate the present greatly increased numbers of undergraduates reading for Moderations and Finals. His staff also will be grateful for the excellent rooms which they now have.

It could only be expected in such times as follow wars that there has had to be a certain amount of improvisation in some directions, and certain desirable items of equipment are still awaited. It must be added, too, that the lecture room will one day have to be entirely reconstructed, and there is a real and urgent need for the proper housing of the research and reference collections, and of a set of rooms for postgraduate and visiting research workers.

J. M. EDMONDS

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AN EXHIBITION OF OILFIELD DEVELOPMENT AT OXFORD

THE exhibition of oilfield development which was open to the public during July 8–20 in the new building of the Department of Geology and Mineralogy at Oxford was arranged by a committee of the British petroleum industry in connexion with the meeting in Oxford of the Fourth Empire Mining and Metallurgical Congress and in order to commemorate the opening of the new building. It is also particularly appropriate that it should have been during "Colonial Month" that the exhibition presented the search for oil and the development of oilfields in countries where British and Commonwealth enterprise has taken the lead.

Since the exploration for and development of oilfields is the foundation of the whole petroleum industry, emphasis in the exhibition was laid chiefly upon the geological and related sciences upon which oil exploration and extraction methods are based, though there were displays showing the wide, and to the outsider, the surprising, range of petroleum products; while the film programmes, shown several times daily throughout the exhibition, dealt with all aspects of oil finding, extraction, transport, refining, and fundamental research into problems such as atomization and microscopy.

The focus of the exhibition was the world map showing the distribution of the oil- and gas-fields of the world and the sedimentary or 'oil' basins spread across the continents, and similar distinctive maps on a larger scale introduced the panels devoted to each country or area separately. One large exhibition room was devoted to countries within the Commonwealth, and by means of topographical and geological maps, sections and photographs of general and specialized nature, the exhibitors were able to hold the interest of visitors of widely varying technical knowledge; further, by series of beautiful photographs, they held the interest of visitors without technical knowledge. It is worthy of remark that here some were first introduced to the fact that there is a producing field at Eakring in Nottinghamshire. The gallery surrounding the central well of the building was given over to displays from the Middle East and Burma, where British enterprise has long taken the lead.

Within the Technical Room (or upper students' laboratory) the applications of the sciences, harnessed to the service of the oil industry, were explained in as 'popular' a manner as possible. Palæontology and the diagnostic value of the micro-fossil content of the rocks had their place, and the visitor was led on to examine the intricacies of geophysical exploration. Specially notable exhibits were the gravity and magnetic maps of southern England not shown in public previously. There was also included the geotectonic map of north-west Germany made by the German Geological Survey (British Zone) under Military Government in the two years after the War (London: H.M. Stationery Office. Scale 1 : 100,000. 25 sheets, £10).

Of the several working models, the outstanding one was of the Schoonebeek oilfield lying across the Dutch–German frontier. This oilfield is now one of the largest in Europe, and it is only because the Dutch successfully deferred its development for four years that the Germans were unable to make use of it to any great extent during the War.

There were displays of drilling and production equipment by several firms, including a modern counterbalanced gear-driven pumping unit which was in action throughout the period of the exhibition. Apart from an impressive display on the second floor of the building by the British Instrument Manufacturers' Association, there were smaller displays of instruments used in surveying and in the exploration for oil.

The British petroleum industry is to be congratulated on the success of this major venture into the educational field, and on the enterprise shown in bringing before the general public this demonstration of the harnessing of pure and of applied science to the needs of one of the most important industries of our day.

SOME ANISOTROPIC PROPERTIES OF GALLIUM

By DR. R. W. POWELL

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SAMPLES of gallium of high purity have recently become available for experimental purposes through the work of the Chemical Research Laboratory on the extraction of this metal from flue deposits[1]. Early this year, a few rods of the metal were supplied to the Physics Division of the National Physical Laboratory for the purpose of investigating some of the thermal and electrical properties of the solid and liquid phases (the melting point is just

below 30° C., and marked supercooling of the liquid phase occurs).

Interest was at once aroused when measurements of the electrical resistivities at room temperature of the first few specimens supplied gave values ranging from about 9 to 51 microhm. cm. Subsequent tests showed the differences to be due to changes in crystal orientation of the specimens, each of which was a single crystal.

The structure of gallium is orthorhombic, so that single crystals of gallium would be expected to have three principal conductivity axes. In order to determine the positions of these principal axes with reference to the seeding crystal, and to determine the electrical conductivities in these axial directions, a single crystal of gallium was grown in glass tubing bent to comprise twelve sections giving four directions in each of three mutually perpendicular planes. Potential leads consisting of fine platinum wires were fused into the glass, so that the electrical resistivity of each section could be determined without removing the solidified metal. The direction of the final section coincided with that of the first, and the fact that the resistivities of these two sections agreed to within 1 part in 500 indicated that the crystal orientation had remained constant during the growth of the specimen.

The individual resistivity values have been found to conform closely to the conductivity ellipsoid obtained by assigning to each radius vector the appropriate magnitude ($\sqrt{\text{conductivity}}$) and direction. The evaluation of this ellipsoid has shown the settings required for growing single crystals of gallium in the three axial directions and has given a first set of values for the electrical resistivities in these directions. The values at 20° C. are $55\cdot_8$, $17\cdot_2$ and $7\cdot8_8$ microhm. cm., that is, the electrical conductivities are in the ratios of 1 : 3·2 : 7.

Single crystals of gallium in the form of rods about 0·45 cm. in diameter and 15 cm. long have been grown in directions conforming approximately with the principal axes. The first set of rods so produced has given the values set out in Table 1 for the electrical resistivity and expansion coefficient.

Table 1. Data for gallium single crystals approximating to the axial directions

Approximate axial direction	Electrical resistivity (microhm. cm.)			Expansion coefficient between 0° and 20° C.
	− 60° C.	0° C.	20° C.	
1	38·9	50·5	54·3	$16\cdot_2 \times 10^{-6}$
2	11·9	16·1	17·4	$11\cdot_3$
3	$5\cdot6_8$	7·5	8·1	31

The resistivity values at 20° C. all agree to within 2 or 3 per cent with those calculated for the axial directions, showing the bars to conform fairly closely with these directions. Further measurements will be made for these and other specimens over a wide range of temperature, and determinations of the thermal conductivity will be included. Preliminary tests by modifications of the Ingen-Hausz and de Senarmont methods, employing cooling by solid carbon dioxide instead of heating, have indicated the ratios of the thermal conductivities for the three axial directions to be of the same order as those for the electrical conductivities.

Recently published tables[2] give 18×10^{-6} as the linear expansion coefficient of gallium and 53·4 microhm. cm. as the resistivity at 0° C. The latter value is presumably due to A. Guntz and W. Broniewski[3]. P. W. Bridgman[4] obtained values of 40·15 and 44·8 at 0° C. and the melting point respectively. No mention has been made of the anisotropic properties of gallium. The purpose of this note is to direct attention to two very important factors associated with this effect: first, the unusual ease with which the single crystals can be produced; and secondly, the unusually high value obtained for the ratio of maximum to minimum conductivity. This can well be appreciated from the electrical resistivity data summarized in Table 2.

Table 2. Extreme values and their ratios for the electrical resistivities of metal single crystals

Metal	Electrical resistivities microhm. cm.		Ratio	Observer
	Maximum	Minimum		
Gallium	$55\cdot_8$	$7\cdot8_8$	7	R. W. Powell
Antimony	42·6	35·6	1·2	P. W. Bridgman (ref. 5)
Bismuth	138	109	1·27	"
Cadmium	8·3	6·8	1·22	"
	8·36	6·87	1·21	E. Goens and E. Grüneisen (ref. 6)
Mercury	23·5	17·8	1·32	O. Sckell (ref. 7)
Tellurium	154000	56000	2·75	P. W. Bridgman (ref. 5)
Tin	14·3	9·9	1·4	"
Zinc	6·05	5·83	1·04	E. Goens and E. Grüneisen (ref. 6)
	6·13	5·91	1·04	P. W. Bridgman (ref. 5)

Most of these results were obtained when examining the dependence of the Wiedemann–Franz–Lorenz Law on crystalline direction. Gallium would seem to offer considerable scope for further investigations in this field, and experiments to this end are in progress.

It seems unfortunate that Bridgman made his measurements on gallium[4] before becoming interested in the directional properties of single crystals[5,8] and so failed to notice the remarkable anisotropy of gallium. He obtained a value of 25·9 microhm. cm. for the resistivity of the liquid at the melting point, and this led him[9] to classify gallium with bismuth and antimony as metals which expand on solidification and for which the resistivity of the liquid is less than that of the solid. This conclusion has been repeated elsewhere[10], but now seems due for revision. The present results agree with Bridgman's value for the liquid state, but indicate a much lower value for the polycrystalline solid and suggest a value for the ratio of the resistivities at the melting point of about 5/3 instead of about 1/2.

I am indebted to Dr. F. M. Reynolds, of the Chemical Research Laboratory, for supplying the gallium and assisting in the preparation of the various specimens, and to Mr. R. P. Tye, of the Physics Division, for assistance with some of the observations. The work described above has been carried out as part of the research programme of the National Physical Laboratory and is published by permission of the Director of the Laboratory.

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CHOLINE AND THE INTESTINAL ABSORPTION OF FAT

FRAZER[1] has reported the presence of large globules of stainable fat in the epithelium of the intestinal villi of rats killed three hours after they had received olive oil and water by mouth; but in the cores of the intestinal villi he could demonstrate very little fat. However, three hours after the oral administration of comparable amounts of olive oil *with added choline*, masses of fat were now found in the cores of the villi, whereas the epithelial cells had been more rapidly cleared. The fat which remained in the epithelium was more finely dispersed. We have re-investigated this problem using various procedures, including that described by Frazer. In a small number of animals the pictures which he has described were seen, but our findings in general have not supported his conclusions.

Experimental. Forty-four young adult rats (100–150 gm.) of the Wistar strain were used, six of which were males, the remainder females. With twenty, Frazer's experimental technique was carefully followed. To normal animals, starved 24 hours, either distilled water (1 c.c.) or 0·5 per cent aqueous choline chloride (1 c.c.) was administered by stomach tube, followed by an equal volume of olive oil. The test meal was not emulsified before feeding, for Frazer[2] has shown that three to four hours after 1 c.c. of olive oil has reached the stomach of a rat, it can be recovered as finely and stably emulsified (0·5 μ) particles from the chyme.

After three hours, the rats were anæsthetized with sodium amytal and killed by the production of double pneumothorax. The gastro-intestinal tract was removed immediately, slit longitudinally, and fixed for at least 48 hours in 10 per cent formal saline. Four fasted rats, receiving no test meal, were used as controls.

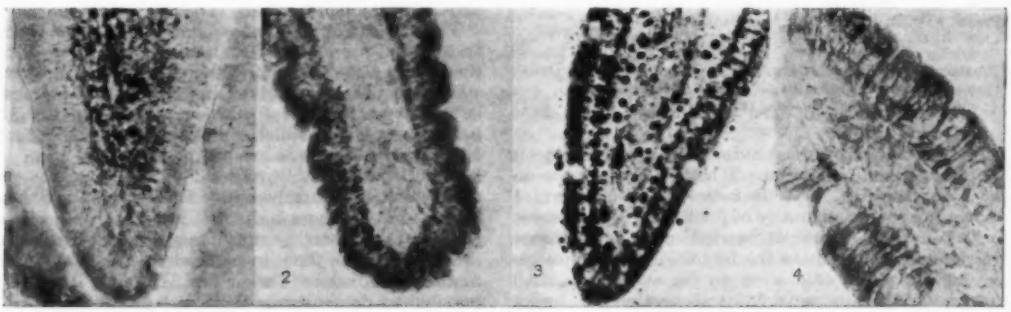
Twenty rats were employed in studies in which variations from the routine procedure described above were introduced. These included altering the dose of choline chloride, emulsifying the test meal, vitally staining the olive oil, feeding choline-deficient and synthetic normal diets before the experiment, allowing ½–6 hours for the fat absorption, and using different anæsthetics. None of these modifications affected the results obtained.

Longitudinal, frozen (5-μ) sections of jejunum were stained for 10 minutes with Sudan IV according to Lillie's technique[3]. One of us (R. R. T.) modified this procedure by substituting 1 per cent Fast Green FCF in 1 per cent aqueous acetic acid (5–30 sec.) for the conventional hæmatoxylin counterstain. This technique was more precise than the classical Sudan IV and hæmatoxylin method[4], which tended to mask small lipid droplets. Sections of other regions of the gastro-intestinal tract were also prepared. The entire small intestine from six of the rats was rolled and imbedded in gelatin so that the total length between pylorus and cæcum was represented on each section. From the tissue of rats fed vitally stained olive oil, 300-μ sections, unstained for fat, were cut to demonstrate the distribution of the absorbed lipid. From the 44 rats, a total of 211 sections was studied.

Results. The accompanying table [p. 156] summarizes the observations made on the 211 intestinal sections which contained appreciable fat. These have been analysed to compare our findings with those that would be predicted from Frazer's report.

In Group I, only eleven of the 69 sections, and in Group II, only two of the 20, support Frazer's observations. It will be noted that even in the intestines of rats fed only fat and water, no constant control picture has been obtained. In general, a fat-filled epithelium was accompanied by an equally well-filled villus core, and the converse was also true. This occurred regardless of the presence or absence of choline in the test meal. When the epithelium was heavily laden with fat, the latter was present in larger globules than when smaller amounts were found.

This again was not affected by the presence of choline in the test meal. We have often observed, moreover, both pictures described by Frazer (Figs. 1 and 2) in different regions of the intestine of the same rat. No difference whatever could be seen



Frozen (5-μ) sections of villi from the upper intestine, stained with Sudan IV (*iso*propyl technique of Lillie) and Fast Green FCF, × 320, photographed with Wratten *G* and *H* filters.

Fig. 1. Abundant fat in the core of the villus, but little in its epithelium. This has been described by Frazer as typical of the intestinal villi of rats three hours after meals of 1 c.c. olive oil plus 1 c.c. of 0·5 per cent choline chloride. (The rat from which the villus illustrated was taken, however, had been given oil and water.)

Fig. 2. Epithelium packed with fat, and the empty villus core described by Frazer as typical of villi taken from rats 3 hours after meals of 1 c.c. olive oil plus 1 c.c. water. (The rat from which this was taken, however, had been given oil and choline.)

Fig. 3. Since different villi from the same rat showed various pictures, it was necessary to analyse the sections according to whether the average picture resembled more closely Fig. 1 or Fig. 2. In many cases the picture was mixed: large amounts of fat in both the epithelium and the core were seen, as in this section. (The rat from which this was taken received oil and choline.) Sections resembling Fig. 3 are described as exhibiting a picture intermediary between Figs. 1 and 2.

Fig. 4. A villus taken from a rat starved 24 hours, which received no test meal. The epithelium contained dust-like, Sudan-positive material, and the core of the villus was devoid of stainable lipid

Experimental group	Supplement fed with olive oil	No. of sections showing a picture described by Frazer as typical of rats fed: (a) fat and choline (see Fig. 1)	(b) fat and water (see Fig. 2)	No. of sections showing an intermediary picture (see Fig. 3)
I All 44 rats studied	Choline chloride	2	8	27
	Water	8	9	15
II 20 rats treated precisely as Frazer prescribed[1]	Choline chloride	0	4	6
	Water	4	2	4

between the fat in the intestines of the normal rats fed oil and choline and those given oil and water.

Finally, Cramer and Ludford[5] found that the amount of stainable fat present in the epithelial cells was increased by the administration of "vitamin B" ('Marmite'), and that this was accompanied by an increase in the size and complexity of the Golgi network. We studied this organelle after impregnation with osmic acid[6]. Although the extent of the Golgi structure varied directly with the amount of fat observed in the epithelial cells, neither was affected by the administration of yeast, cod liver oil concentrate or choline chloride.

Summary and Conclusion. The experiments described above were designed to investigate the histological evidence for the alleged effect of choline on fat absorption. All known variables influencing fat absorption, including those outlined by Frazer, were carefully controlled. The results provide no support for the claim that choline affects the distribution or dispersion of fat in the intestinal villi during fat absorption.

We wish to thank Prof. C. H. Best for his helpful advice.

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Prof. C. H. Best has invited me to comment on the above communication. I have already done so privately to Prof. Best last October; however, I appreciate this opportunity of publishing my remarks.

Tasker and Hartroft carried out experiments "designed to investigate the histological evidence for the alleged effect of choline on fat absorption. All known variables influencing fat absorption . . . were carefully controlled." Their experiments consist of histological studies on 44 rats. In a group of 20 animals they attempt to repeat some experiments of mine[4]. They claim to have studied and accurately assessed more than twelve variables in a further group of 24 rats.

The problem of the effect of choline on fat absorption is a living dynamic problem. Fat is absorbed through the intestinal cells and passes from them through the corium of the villus to the lacteal. Quite clearly the presence of fat in the corium of the villus depends upon the relationship of the rate of transference of fat from the cells into the corium and the rate of removal from the corium into the lacteals. The amount observed is obviously not only dependent on the relative rates, but also upon the actual quantities of fat being transported, and, possibly, on the state of dispersion of the fat. These various factors are in turn dependent upon the amount of fat fed, the gastric emptying-rate, intestinal motility, and the presence of phosphate and other substances. It is possible in a long series of carefully planned experiments to obtain reasonably consistent results histologically. Even so, morphological studies alone do not justify any firm conclusion, because fundamental quantitative information is lacking.

In order to assess the histological picture of fat absorption, or to compare or contrast it with any other observation, it is essential that certain important variables should be controlled and some of them quantitatively assessed. The most important points are stomach emptying-time, the quantity of fat absorbed, the presence of choline or choline-containing substances from other sources, and the presence or absence of phosphates. Tasker and Hartroft have neither controlled nor investigated any of these vitally important factors in their experiments.

They state that their Fig. 1 would be described by me "as typical of the intestinal villi of rats three hours after meals of 1 c.c. olive oil plus 1 c.c. of 0·5 per cent choline chloride". It certainly would not. The relatively small amount of fat in the corium of the villus and the completely cleared intestinal cells 3 hr. after the administration of 1 c.c. of olive oil is, in my experience, more probably due to interference with gastric and intestinal motility than to choline. Such an appearance may be seen in monoiodoacetic acid intoxication, which causes gross interference with gastric and intestinal motility. Fig. 2 shows moderate loading of the intestinal cells. Fig. 3 is rather more like the choline effect than Fig. 1, if faulty fixation can be excluded. None of the photographs reproduced in their paper shows a characteristic choline effect as described by me. Using these histological criteria, it is scarcely surprising that the results of their investigations do not agree with mine.

The effect of choline cannot be demonstrated unless an adequate amount of fat is available to overload the cells; hence the importance of normal gastric-emptying. The table given by Tasker and Hartroft is said to summarize the observations "on the 211 intestinal sections which contained appreciable fat". It actually shows the results of not more than 89 sections. Presumably at least 122 sections (58 per cent) contained no appreciable fat at the end of three hours—and 14 more may well have been associated with delayed gastric-emptying. From these figures it would appear that, in at least 64 per cent of the material studied by Tasker and Hartroft, it was not possible to demonstrate the effect of choline due to lack of sufficient fat to overload the intestinal cells.

Since none of the important variables most relevant to the problem were controlled or measured, and since the histological criteria used for assessment were incorrect, the conclusions of Tasker and Hartroft are not valid.

Since the preliminary note on the possible effect of choline on fat absorption, we have developed methods for the simultaneous histological and biochemical study of fat absorption. Using these methods with my colleague, Dr. P. E. Sagrott, we

have shown that added choline causes a significant increase in the amount of fat absorbed in a standard experimental period of 3 hr. Three control groups of 10 rats per group were fed 916 mgm. of olive oil per 200 gm. rat with 1 c.c. of water by gastric tube, and the amount of fat absorbed was determined after 3 hr. The mean absorption in each group was 328, 324 and 345 mgm. respectively, with standard deviations of 44, 32 and 40 respectively. When 10 mgm. of choline were added to the same quantity of fat in two groups of 10 rats, the mean absorption in 3 hr. was 500 and 528 respectively, with standard deviations of 69 and 72 respectively. The increase in absorption of 52 per cent and 59 per cent in these two groups, due to the addition of choline, is statistically significant. I therefore have no hesitation in re-affirming that the addition of choline to long-chain triglyceride fat in some way facilitates its absorption from the small intestine. As stated in the publication referred to by Tasker and Hartroft[1], we are still investigating the possible relationship of choline to the fat absorption mechanism, and we have not yet come to any final conclusion in this matter.

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Medical School, Hospitals Centre,
Birmingham 15. May 21.

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BIOLOGY IN THE MEDICAL CURRICULUM

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FROM time to time during the last twenty years, articles have been published dealing with the teaching of elementary biology, usually with particular reference to the medical curriculum at the First M.B. (or equivalent) stage. It is true to say, however, that, generally, little change in the teaching syllabus has been brought about; the plant studies may be of a more physiological nature than twenty years ago and minor changes in the types of animals to be studied may have been made, and yet no change has been really fundamental. In fact, reference to the prospectus of Guy's Hospital Medical School of 1895 shows that little change in the main structure of the course has taken place since then.

In this article I propose to raise the question as to whether a more fundamental change is necessary, and if so, to survey the lines along which it might travel. My reason for raising this well-worn topic at this time is that the universities are now making known their requirements for matriculation in relation to the new school examination, and it is quite obvious that the whole system of examinations as we have known it will have to be recast. From this rearrangement the first-year medical examinations cannot be excluded. It may be noted that the new school examination departs markedly from the scheme envisaged in the Norwood[1] Report and which the Goodenough[2] Report assumed as a basis for its consideration of the initial stages of the medical curriculum. In particular, the training in the elementary sciences which it will be safe to assume is possessed by the first-year medical student will certainly be much less than that assumed by the authors of the Goodenough Report, and thus their recommendations on the organisation of the first-year teaching are based on a false foundation. The Committee of the British Medical Association, reporting on the medical curriculum[3], disagreed with the conclusion of the Goodenough Committee that the standard of basic training in physics, chemistry and biology which could be reached in the schools would be sufficient for a medical education. The new certificate and the matriculation arrangements with relation to it, which have recently been announced, will, in my opinion, make it quite certain that the B.M.A. Committee is right and the Goodenough Committee is wrong concerning the training in basic science for medical students.

The First M.B. problem is, therefore, a very live one, and in view of the new certificate's impending introduction, an urgent one. The points I wish to discuss here, however, are not those related to examination regulations, etc., but to the educational content of the courses. Is any great change needed? If there is, then surely the present time, when changes have to be made in the regulations, is the correct time to overhaul the educational content of the courses too. My remarks will be confined to the subject of biology.

It will, I believe, be not without profit to consider what the subject 'biology' is, and why it is taught to medical students.

Biology is the science which deals with the integration of those principles concerning the nature, properties and interrelation of living matter which are observed and deduced by the exercise of the separate disciplines of the various 'biological sciences', such as zoology, botany, biochemistry, palæontology, etc. Biology is not, as it is so often considered, a mere jumble of botany and zoology. Biology is not even an observational science at all; it is entirely concerned with observations derived for it by the application of one of its numerous branches. We often speak of making a 'biological observation'; but, although this may be a convenient phrase, it is quite impossible. The observations can only be made by the use of the methods of one or more of the biological sciences, zoology, botany, etc., referred to above.

If we accept this definition of biology we can quickly see the most important problem with which a teacher of biology is presented. It is this: a university student working for a degree in pure science on the biological side follows the discipline of one or more of the biological sciences for at least three years. During that time he comes to appreciate all the biological principles on which his particular sciences throw light, and if he is a true 'biologist', can see, as a matter of course, the great biological principles which govern all life. His medical contemporary, however, has at most one year in which to learn to appreciate these same biological principles, and it follows, quite obviously, that his teachers, while giving him every opportunity to follow the disciplines of the separate biological sciences to see how 'biological' facts are ascertained, will have to spend considerable time dealing with those principles of the subject which the science student will absorb as he goes along.

But, it may be asked: Why, if you are trying to produce a medical practitioner, should he have to be a biologist first? The answer is this: the importance of the medical man to the human race is so great that the fact that he is really only a highly skilled and specialized applied biologist is frequently overlooked. Most medical men would probably be very

hurt by being told that they were applied biologists; but if the matter is considered without preconceived ideas it is seen to be a correct statement of fact. Obviously, one cannot produce an applied specialist of any kind unless his basic training in pure science is adequate, and as a medical man is an applied biologist his biology must be considered his basic training.

We now have to consider what this basic training should be, and we may note, in passing, how the present system of a jumble of botany and zoology (often through force of circumstances taught in two separate departments) meets, or fails to meet, its requirements.

It is probably true to say the principles of biology are so few that an experienced speaker could make them intelligible to an adult audience in not more than a dozen talks. This does not mean, however, that if this were to be done we should become a nation of biologists. Part of the training of a biologist is, as has been stated above, first-hand knowledge of biological material. He must learn to make observations at the biological level. This is what the student finds so new in biology as compared with physics and chemistry. He has to learn that an observation on an animal or plant can be 'exact' without being mathematical; and it is this training that is so useful to the medical student, for, despite many scientific aids to diagnosis, the greater part of the clinical examination of a patient is precisely a similar series of observations. The methods of diagnosis of diseases are precisely similar to the methods of remembering and 'spotting' specimens which he uses in the biology course.

Abercrombie and Johnson[4] have emphasized that part of the first-year training of a medical student should be devoted to training in scientific observation, the students being taught to observe for themselves. The traditional biology course makes no allowance whatever for this training. So long as biology practical examinations continue on traditional lines, in which the student is expected to perform one of a number of standard dissections or to demonstrate the anatomy of a root or stem or leaf by the drawing of sections, observational training will have little place in our courses.

For a student to reach the required degree of skill in dissection in the limited time available, things have to be made easy for him in that what he is expected to find is described to him before he begins. The remedy would seem to lie in a new approach to practical work and practical examinations. At present too much emphasis is placed upon manual dexterity rather than any ability to observe and to make intelligent deductions.

A beginning in observational training has been made by the setting of unknown objects, not in the syllabus, for description in certain School Certificate papers. As one who has marked answers to such questions, I can only say that the average schoolboy who has had a secondary school course leading to the School Certificate is quite incapable of describing anything for himself. He expects to be taught how to describe each object separately.

Thus far it would seem that so long as the principles of biology are looked after, any course in botany and zoology might suit our student; and, indeed, in many places he is taught along with science students in these subjects. But it is possible, and I believe highly desirable, to provide the medical student with a special course of his own. One of the chief reasons for this view is that the knowledge of vertebrate types (for example, the dogfish, frog and a mammal such as the rabbit) required by the two categories of student is quite different. To the student of zoology a fairly detailed knowledge of the structure of these types is essential, for on this foundation he will build comparative studies over the rest of his student career. The medical student's requirements are quite different. He should study vertebrate zoology in view of its importance in understanding the body of man. His knowledge of the Vertebrata should be such as to enable him to appreciate: (*a*) That every organism is a living whole (in particular, such abstractions as the 'evolution of the vertebrate heart' should be carefully avoided; the heart can only exist inside a living animal). (*b*) That the present form of the mammalian body has been derived, by an evolutionary process, from a simpler form such as may be more or less approximate to that of certain living fishes; and that such an evolutionary process accounts for such things as the mammalian double circulation. (*c*) That some of these changes can be followed in embryological development and that abnormal development may give rise to congenital disease. (*d*) That embryological development consists of a regular process of differentiation which works along rules which are capable of investigation (there is no reason for this study to be restricted, as has been generally the case, to the vertebrates; there is no reason why invertebrates, in which fertilization itself is readily demonstrable, should not be introduced).

It is quite obvious that such a study as outlined cannot be made by a mere comparison of the dogfish, frog and the rabbit. The course must be a proper study of vertebrate evolution which will draw its evidence not only from comparative anatomy, but also from palæontology and every source of evidence. There is no reason why the course should stop at the rabbit; man can be introduced at the proper place. This is an instance of integration between biology and anatomy. Integration of biology and anatomy which is so much advocated in certain quarters does not mean that biologists should be employed in teaching elementary anatomy, and so saving time in the later pre-clinical years. The foundation of pure biology must be carefully laid before anatomical details are allowed to obtrude unduly.

Certain principles which should guide the revision of the syllabus, so far as the vertebrata are concerned, have been outlined. A part of the syllabus against which considerable criticism has been directed is the botany portion. Some botany must be included in our course, for one of our principal duties is to outline the whole of the living world, including animals, plants, bacteria and even viruses, and to sketch their relationships to each other. A few years ago a case might have been made for the exclusion of the fungi. Nowadays, with the increasing importance of antibiotics of a fungal nature, nobody would advocate such a course. The main weight of the criticism is against the study of the anatomy of the flowering plant; this, however, is essential for the study of plant physiology, and plant physiology is itself of great importance as an introduction to general physiological methods. The real weakness of the present system is that plant physiology is overemphasized and animal physiology scarcely mentioned. Just as the biology course should lead naturally on to anatomy, so also it should lead on to physiology. There is no justification for the attitude

adopted in the Goodenough Report (p. 133) which suggested that biology should be taught along with anatomy, and only to a lesser extent with physiology. Such a suggestion could only result from the complete failure to appreciate what biology is and why it is taught to medical students.

To conclude: the biology course for medical students requires modification. It must clearly set out the fundamentals of biology, including the laws relating to living matter and the study of heredity. The student will follow certain branches of the disciplines of zoology and botany and thus obtain experience of the methods of the biological sciences. He will learn to make observations both at the biological level and on living objects. Both plant and animal kingdoms will be surveyed; advantage will be taken to direct attention to the animals and plants directly affecting man, particularly those which attack or parasitize him. Man's own position in the realm of living things will be made clear, and the student will learn to appreciate plants and animals as 'going concerns' from the moment of syngamy until the death of the individual. When we have such a course it may be possible to begin to dispel the illusion that 'biology' and 'the frog' are synonymous.

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NEW TRIODE FOR CENTIMETRE WAVES

THE rapid and spectacular development of television in the United States has directed attention to several problems associated with the use of radio relay systems on centimetric wave-lengths, and the Bell Telephone Laboratories are actively engaged in the solution of these problems. The radio television relay system which is already working between New York and Boston operates on a frequency in the region of 4,000 Mc./s., and uses amplifiers incorporating velocity-modulated tubes. Experience has shown that while such tubes are satisfactory for their present purpose, they suffer from a number of limitations which render them unsuitable for long-distance relay work such as will be required to reach from coast to coast across America. As a result, consideration has been given to the possibilities of developing a triode valve which will have an effective amplification at the above frequencies, and the successful production of a suitable valve is described in an article by J. A. Morton in the May number of *Bell Laboratories Record* (**27**, 166).

This microwave triode, designated as *BTL* 1553, is an improved planar triode in which by careful design and very skilful mechanical construction the grid-cathode spacing has been reduced to less than the thickness of the oxide coating used on the cathodes of older types of triodes for very high frequencies. The cathode is a nickel core mounted in a ring of low-loss ceramic in such a manner that the nickel and ceramic surfaces may be ground flat and co-planar to a high degree of precision. An oxide coating, 0·5 mil thick, is sprayed on to the upper surface of the cathode. The grid wires, 0·3 mil in diameter, are wound at 1,000 turns per inch on a molybdenum frame that has been previously gold-sputtered; this grid frame is separated from the cathode ceramic supporting-ring by a thin copper skin, and the whole riveted together with three synthetic sapphire rods. The anode is separately supported with a spacing of 10 mils from the grid.

Production yields of such triodes have been successfully obtained under carefully controlled conditions, and show that they have advantages over the velocity-modulated tubes in giving a greater gain for a larger band-width and for a lower operating voltage. The low-frequency characteristics of the triode show that working at an anode voltage of 250, and current of 25 milliamp., the transconductance of the tube is about 2,000 μ mhos per milliamp., while at lower operating currents this figure is greater. A wave-guide amplifier circuit for this triode has been developed and incorporates resonant cavities and coupling windows such that the amplifier may be tuned and matched to the wave-guide over a frequency range 3,700–4,200 Mc./s. In this way, and with a bandwidth of 120–170 Mc./s., a gain of 7–10 db. can be obtained. The type 1553 triode also works well as a modulator valve and as a harmonic generator. These properties make the valve very suitable for long-distance radio relay systems, in that they make possible improved repeaters which do not require excessively high voltages, and which, for about half the power consumption, provide much better transmission characteristics than have hitherto been available.

The production of this type of valve provides an excellent illustration of the manner in which, when the need arises, old ideas may sometimes be successfully resurrected and, in conjunction with new techniques and materials, made to yield revolutionary results.

FOOD AND WORLD POPULATION

IN August 1948 delegates from twenty different countries met at Cheltenham to consider the problem of rising populations throughout the world and the resources of food, clothing and housing available to meet their needs. The Congress was presided over by Lord Horder, and after papers had been presented by speakers of international authority, deliberations proceeded by means of four discussion groups which considered: (1) current research in problems of contraception; (2) research in sub-fertility and sperm resistance; (3) international liaison, including the present situation in Germany; and (4) sex education and marriage guidance. ("Proceedings of the International Congress on Population and World Resources in Relation to the Family." H. K. Lewis. 10*s*. 6*d*. net.)

The first discussion group considered the present world food crisis, and since this is due, in part, to the growing pressure of the population on food and other resources, the Congress agreed to invite all national Governments and appropriate international organisations to make every effort to initiate positive population policies in accordance with the situation in their respective areas, and to make available knowledge of and advice on family planning techniques to the peoples of the world.

Governments were also encouraged to take action to encourage and finance research into the basic problems of human fertility and infertility.

It was also resolved that a provisional international committee should be established to promote research and education for the furthering of human welfare through planned parenthood and progressive sex education. (This committee has since been constituted, and the secretariat has been established at the offices of the Family Planning Association of Great Britain, 69 Eccleston Square, London, S.W.1.)

The fourth resolution was concerned with sex education and marriage guidance, and the Congress agreed that sex education for family life should be a continuous process designed to give biological, psychological and spiritual understanding in the principles of personal relationships to the peoples of the world, so that they can acquire standards of responsible behaviour in their sexual life which are devoid of fear and guilt and are in a wise relationship, not only to their religious and cultural background, but also to the needs of mankind in general. Means of promoting sex education were also agreed to by the members of a memorable and important Congress.

FORTHCOMING EVENT

Friday, July 29

BIOCHEMICAL SOCIETY (in the Biochemistry Department, University College, Dundee), at 11 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN GEOLOGY, if possible with special training or interests in Mineralogy and Petrology—The Registrar, University College, Hull (July 30).

LABORATORY TECHNICIANS (lower grade) IN THE DEPARTMENTS OF CHEMISTRY and of MATHEMATICS AND PHYSICS—The Principal, Municipal Technical College, Hopwood Lane, Halifax (July 30).

ASSISTANT EXPERIMENTAL OFFICER IN THE ENTOMOLOGY LABORATORY, to assist in recording and compiling research data on fruit pests—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (July 30).

LECTURER IN ORGANIC CHEMISTRY at the Coventry Technical College—The Director of Education, County House, Coventry (July 30).

LECTURER IN MATHEMATICS, a LECTURER IN METALLURGY, a LECTURER IN PHYSICS, and a LECTURER IN BIOLOGY, at the Constantine Technical College—The Director of Education, Education Offices, Woodlands Road, Middlesbrough (July 30).

LECTURER IN PHYSICS—The Registrar, Technical College, Sunderland (July 30).

DEMONSTRATOR IN THE PHYSICS DEPARTMENT—The Warden and Secretary, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1 (July 30).

POWER-GAS CORPORATION, LTD., ENTRANCE SCHOLARSHIP—The Registrar, The University, Leeds 2 (July 31).

VETERINARY OFFICER to take charge of an establishment for the breeding and supply of laboratory animals and to pursue research in cognate matters, at the John Curtin School of Medical Research—The Administrative Officer in the United Kingdom, Australian National University, 6 Gordon Square, London, W.C.1 (August 1).

SCIENTIFIC ASSISTANT (with a First-Class Honours degree in Science or Engineering) IN THE SCIENTIFIC LIBRARY of the Research Department—The Principal Staff Officer, British Transport Commission, 55 Broadway, London, S.W.1 (August 2).

LECTURER IN BOTANY—The Registrar, King's College, Newcastle-upon-Tyne (August 7).

PRINCIPAL SCIENTIFIC OFFICER in the Mathematics Division, a PRINCIPAL SCIENTIFIC OFFICER (Physicist) to take charge of team working on large-scale trials of methods of heating dwellings, and a SENIOR EXPERIMENTAL OFFICER for the Building Practice Division for work on technical inquiries and inspection of buildings, at the Building Research Station of the Department of Scientific and Industrial Research—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2640 (August 10).

EXAMINER IN THE STANDARDS DEPARTMENT of the Board of Trade—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2631 (August 10).

CHARLES BROTHERTON SCHOLARSHIPS in the Department of Coal Gas and Fuel Industries with Metallurgy—The Registrar, The University, Leeds 2 (August 14).

PROFESSORS of (*a*) BIOLOGY, (*b*) MATHEMATICS, (*c*) PHYSICS, (*d*) CHEMISTRY, and (*e*) ENGLISH LANGUAGE, at the Iraqi College of Arts and Science—The Cultural Attaché, Iraqi Embassy, 22 Queen's Gate, London, S.W.7 (August 15).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, Queen Mary College, Mile End Road, London, E.1 (August 15).

HEAD OF THE DEPARTMENT OF SCIENCE at the Royal Military Academy, Sandhurst—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 2667 (August 16).

SENIOR LECTURER IN MECHANICAL ENGINEERING, a LECTURER IN CHEMISTRY with special qualifications in Physical or Inorganic Chemistry, a LECTURER IN ZOOLOGY, a TEACHER OF CHEMISTRY, and a TEACHER OF PHYSICS—The Principal, College of Technology, Belfast (August 19).

LECTURER IN MATHEMATICS in the United College, St. Andrews—The Secretary, The University, St. Andrews (August 20).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Liverpool (August 27).

ASSISTANT LECTURER IN PHYSICS—The Secretary and Registrar, University College of North Wales, Bangor (August 29).

LECTURER IN MECHANICAL ENGINEERING—The Principal, Heriot-Watt College, Edinburgh (August 31).

DIRECTOR OF A LIVESTOCK RECORDS BUREAU to be established in the Department of Agriculture for Scotland in Edinburgh—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.204/49 (August 31).

ASSISTANT KEEPER IN ETHNOLOGY AND GENERAL ARCHÆOLOGY in the Manchester Museum—The Registrar, The University, Manchester 13 (September 1).

SENIOR LECTURER IN MECHANICAL ENGINEERING at Canterbury University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 15).

PROFESSOR OF BACTERIOLOGY in the University of Queensland, Brisbane—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Brisbane, September 15).

ASSISTANT DIRECTOR OF THE COMMONWEALTH BUREAU OF ANIMAL BREEDING AND GENETICS, Edinburgh—The Secretary, Commonwealth Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1 (September 16).

LECTURER (Grade I) IN COMPARATIVE PHYSIOLOGY in the Department of Zoology—The Registrar, University College, Southampton (October 8).

PLANT PHYSIOLOGIST in the Research Division of the Ministry of Agriculture, Sudan Government—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Physiologist'.

SUGAR AGRONOMIST in the Department of Agriculture, Trinidad—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

LECTURER IN THE DEPARTMENT OF OPHTHALMIC OPTICS—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

SCIENTIFIC OFFICER (Meteorologist) IN THE ROYAL OBSERVATORY, Hong Kong—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

AGRONOMIST IN THE RESEARCH DIVISION of the Ministry of Agriculture and Forests, Sudan Government—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Agronomist'.

LECTURER IN BIOLOGY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

SCIENTIFIC ASSISTANT (woman) in a team engaged on research into the 'Sudden Death' disease of cloves in Zanzibar—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

TECHNICAL ASSISTANT TO THE DIRECTOR—The Secretary, Gas Research Board, The Abbey, Southend Road, Beckenham, Kent.

VALUERS (fully qualified Agricultural Valuers) IN THE LAND SETTLEMENT DIVISION of the Department of Lands and Mines, Tanganyika—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

CHEMIST or METALLURGIST to study the marine corrosion of non-ferrous metals, and a METALLURGIST to investigate general problems in physical metallurgy such as phase equilibria—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1.

ASSISTANT INVESTIGATOR ON UNDERGROUND DUST SUPPRESSION—The Divisional Establishment Officer, National Coal Board, North-Western Division, 47 Peter Street, Manchester 2.

JUNIOR CHEMIST (with Honours Degree in Chemistry) for research and development work—The Superintendent of Laboratories, British Scientific Instrument Research Association, 'Sira', Southill, Elmstead Woods, Kent.

MYCOLOGIST to develop suitable methods of testing and recording the incidence of diseases in new varieties of crops—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

TECHNICIAN (with proficiency in thin section preparation and photography) IN THE DEPARTMENT OF GEOLOGY—The Bursar, The University, Western Bank, Sheffield.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research and Fire Officers Committee. Report of the Fire Research Board, with the Report of the Director of Fire Research for the Year 1947. Pp. iv+35+9 plates. (London: H.M. Stationery Office, 1949.) 1*s.* 3*d.* net. [12

International Council of Scientific Unions. Report of the Executive Committee, 1948. Pp. vii+110. (Cambridge: Prof. F. J. M. Stratton, Gonville and Caius College, 1949.) 5*s.* [12